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RECENT ADJUSTMENTS IN THE ORGANIZATION OF CANADIAN AGRICULTURE[1]

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In discussing Canadian agriculture, even before such a well informed group as the International Conference of Agricultural Economists, it seems advisable to give a brief outline of the important agricultural areas of the country, and the types of farming they support. May I begin this discussion with extracts from the concluding paragraph of my paper at Ithaca in 1930:

"With the exception of the maritime and central provinces, there is little uniformity or continuity of agricultural areas, as may be seen from the accompanying map of the Dominion of Canada showing the main types of farming. In most cases the agriculture of the Canadian areas resembles fairly closely that of the areas of the States adjoining them, of which they are naturally a part. The tremendous geographical obstacles between the areas increase the difficulties of communication, transportation and distribution. The people of the different sections find it difficult to understand each other's problems, both in agriculture and in industry generally. Recent depressions have made the problems of each area more acute, and have tended to confine and concentrate the attention of the farmers of each area on their own problems. The barriers between the agricultural and general Canadian economic regions retard the general movement of commodities. Most Canadian agricultural areas produce more than is needed locally, and the surpluses resulting have to be disposed of in outside markets, where they encounter heavy competition, and meet serious political and economic obstacles."

For the purposes of this discussion, the provinces have been arranged in four groups according to their location, and the type of agriculture carried on. In the east is the maritime group consisting of Prince Edward Island, Nova Scotia and New Brunswick. Over this area, the climate is generally temperate favouring dairying and the growing of potatoes, apples, and other fruits, much of which is sold in the markets of Britain. Although official estimates include three-fifths of the total area as potential farm land, only one-half of this potential farming area has been included in farms to date, and the occupied area in 1931 was 12% less than in 1911. Field crops occupy about 20% of the land in farms.

Quebec and Ontario are included in the central group. Most of the agricultural portions of these provinces are favoured with a temperate climate. Here are located the densest centres of population in Canada,

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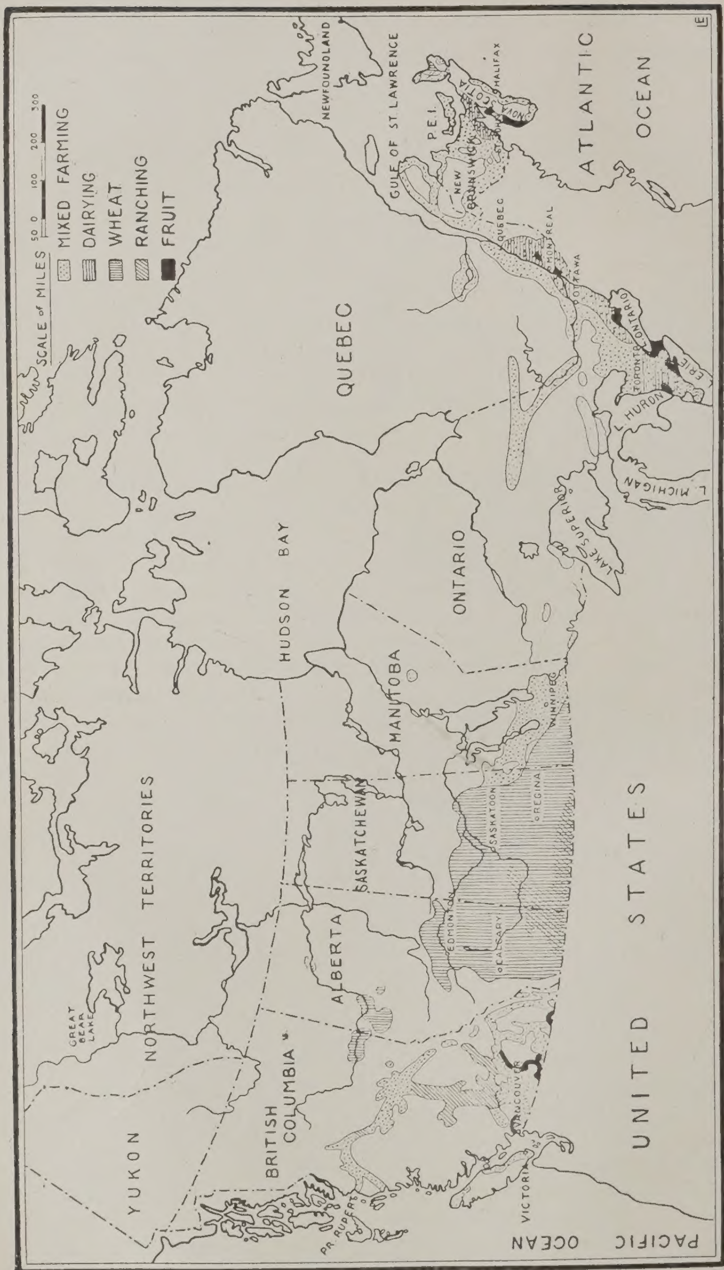

MAP OF THE DOMINION OF CANADA SHOWING MAIN TYPES OF FARMING

and local conditions and markets determine largely the type of agriculture, which is quite diversified in character. Good pastures and abundant hay and forage crops favour dairying enterprises over much of these agricultural areas. Fruit growing is important in many areas, particularly in the Niagara district of Ontario. About one-fifth of the land is considered to have potentialities for farming. Developments to date include about 37% of this potential area in farms. Since 1911 the farm area has increased about 7%. About 37% of the farm land is used for field crops.

The prairie provinces of Manitoba, Saskatchewan and Alberta form the third group, which includes about two-thirds of the occupied farm lands of the Dominion. These lands are used chiefly for grain production. The climate is more extreme than in the other agricultural areas of Canada. The frost-free period is fairly short, rainfall limited and variable, and the choice of farm enterprises is severely restricted by nature and markets. The agricultural lands are practically all situated in the southern half of these provinces. Official estimates include 44% of the total land area as potential farm land. By 1931 about 55% of the potential farm land had been reported in occupied farms. Since 1911 the settled area has almost doubled. Field crops account for about 37% of the farm land, and summer-fallow another 9 or 10%.

British Columbia, on the Pacific Coast, separated from the prairie provinces by the Rocky Mountains, constitutes the fourth area. Its agriculture is principally found in the mountain valleys and the coastal plains. Its mild climate and abundant rainfall favour dairying and fruit growing. Poultry farming is of considerable importance. In the hilly areas the cattle ranches and sheep ranges are located. The coastal cities have developed into popular residential and holiday centres and draw largely from the prairie provinces. Less than one-tenth of the total land area is officially considered to have potentialities for agriculture and only 16% of such land has been occupied to date. About one-eighth of the farm land is used for field crops. Census reports indicate that the area in farms increased about 40% from 1911 to 1931.

Table 1 summarises data from official sources relating to the estimated area of land, of potential farm land, occupied farm land, and field crops for the four regions of Canada, and for the Dominion as a whole.

THE GENERAL ECONOMIC SITUATION IN CANADA

The 15 years from 1921 to 1935 include extremes of business activity and depression. These may be conveniently divided into three five-year periods of economic experience. Following the World War, conditions were generally depressed, but recovery commenced during the first five years, and developed to produce the business activity and boom of the second period, which in turn was followed by the acute and prolonged depression from which recovery is being initiated.

The greatest volume of Canadian business since 1921 was in 1929, but it ranged high for the full five-year period from 1926 to 1930. The smallest volume of business came in 1932 and 1933, when the amount of freight carried by the railroads was only about one-half of that reported for 1929. Construction was most active in 1929, but slowed down rapidly, and practically ceased in 1932. Unemployment reported by the trade

unions was at the minimum in 1928 when only 4% of the registered membership lacked work. In 1933, the average percentage unemployed was 22.3. Some recovery has since been recorded, but around 15% were out of work in April 1936.

TABLE 1.—ESTIMATED AREA OF LAND, POTENTIAL FARM LAND, OCCUPIED FARM LAND, AND FIELD CROPS IN CANADA BY PROVINCES

Provinces	(1) Total land area millions of acres	Estimated potential farm land		(3) Occupied as farm land, 1934, millions of acres	(4) Per cent of potential farm land occupied in 1934	(5) Total area of field crops averages per year, millions of acres		
		Millions of acres(2)	Per cent of total land area			1921 to 1925	1926 to 1930	1931 to 1935
Maritime:								
Prince Edward Island	1.40	1.26	90.1	1.19	94.4	0.53	0.54	0.48
Nova Scotia	13.28	8.09	61.0	4.30	53.1	0.73	0.72	0.54
New Brunswick	17.73	10.72	60.4	4.15	38.7	1.01	0.90	0.89
Total	32.41	20.07	61.9	9.64	48.0	2.27	2.16	1.91
Central:								
Quebec	335.06	43.74	13.1	17.30	39.6	7.14	7.01	5.83
Ontario	232.50	65.84	28.3	22.84	34.7	10.25	10.23	9.12
Total	567.56	109.58	19.3	40.14	36.6	17.39	17.24	14.95
Prairie:								
Manitoba	140.63	32.38	23.0	15.13	46.7	6.70	6.48	5.89
Saskatchewan	152.30	80.07	52.6	55.68	69.5	20.03	21.05	21.08
Alberta	159.23	87.45	54.9	38.98	44.6	10.09	11.68	13.55
Total	452.16	199.90	44.2	109.79	54.9	36.82	39.21	40.52
Pacific:								
British Columbia	229.94	22.60	9.8	3.54	15.7	0.37	0.40	0.45
Dominion Total	1,282.07	352.15	27.5	163.11	46.3	56.85	59.01	57.83

(1) Canada Year Book 1934–1935, page 1108, line 32; (2) Ibid, line 14; (3) Ibid, line 1; (4) Calculated. (5) Based on data from January issues of Monthly Bulletins of Agricultural Statistics, Ottawa.

Canada's economic welfare is closely tied up with its export trade, which since 1929 has been greatly reduced in value and in volume. Reductions of imports have also been considerable, but not to the extent indicated for exports.

The index of wholesale prices of all commodities dropped to its lowest level for the last 15 years in February 1933, when it was 63.5% of the 1926 base. It recovered somewhat in 1934 and 1935. The index of the cost of living in Canadian cities was practically stationary from 1922 to 1930, but declined to its minimum of the 15-year period in 1933, when it reached 78% of the 1926 level.

Table 2 presents some selected indexes of significant economic data prepared by the Bureau of Statistics at Ottawa relating to the Dominion of Canada.

GROSS AGRICULTURAL PRODUCTION

From 1921 to 1935, the various classes of commodities included in the official statement of the gross agricultural production of Canada were indicated to have a combined average annual value of 1,332 millions of

TABLE 2.—SIGNIFICANT CANADIAN DATA OF THE POST-WAR PERIOD INDEX NUMBERS OF BUSINESS AND PRICES, (1926 = 100)(1)

—	Physical volume of business	Industrial production	Distribution	Construction	Employment per cent T.U.(2)	Agricultural marketings	Grain marketings	R.R. freight loadings	Exports value	Imports value	Wholesale prices	Cost of living
1921	66	60	84	70	87	65	64	74	112	122	110	109
1922	79	77	85	92	93	83	83	83	94	103	97	100
1923	86	84	90	85	95	91	93	92	93	112	98	100
1924	85	82	91	80	93	102	104	86	95	108	99	98
1925	91	90	94	83	93	97	97	88	103	106	103	99
1926	100	100	100	100	100	100	100	100	100	100	100	100
1927	106	106	107	119	95	104	105	98	98	96	98	98
1928	117	118	116	134	96	147	159	112	94	97	96	99
1929	126	127	120	164	94	101	104	102	93	94	96	100
1930	110	108	114	130	89	103	108	88	80	88	87	99
1931	94	90	102	91	83	99	103	69	65	73	72	90
1932	79	74	92	43	78	114	122	58	58	69	67	82
1933	80	77	88	28	78	105	112	55	59	68	67	78
1934	94	94	96	36	82	88	90	65	65	73	72	79
1935	102	104	99	52	85	87	88	73	80	77	72	79
Averages:												
1921 – 1925	81	79	89	82	92	88	88	85	99	110	102	101
1926 – 1930	112	112	112	129	94	111	115	100	93	95	95	99
1931 – 1935	90	88	96	50	81	99	103	64	65	72	70	82
1921 – 1935	94	93	99	87	89	99	102	83	86	92	89	94

(1) Based on data in "Recent Economic Tendencies in Canada 1919-1934", "Prices and Price Indexes", and current issues of "Monthly Review of Business Statistics,"—Dominion Bureau of Statistics.

(2) Not an index—percentage of registered numbers of trade unions employed.

dollars. During the central five-year period the gross production from agriculture averaged 1,649 millions of dollars per year, which was about 11% higher than prevailed during the first period, but from 1931 to 1935 the average annual gross value was so drastically reduced that it amounted to only 52% of that of the preceding five years, or 64% of the average for the full 15 years.

Of the various sections of Canada, the prairie provinces have shown the greatest reduction in gross agricultural production, which from 1931 to 1935 averaged about 45% of that of the preceding five years, or 58% of the average from 1921 to 1935. Saskatchewan experienced by far the heaviest decrease, and values of the production of the last five years were brought down to 45% of those of 1926 to 1930, or 48% of the average of the full 15 years 1921 to 1935.

The grain crops of Canada are the principal producers of farm revenues, of which wheat is by far the most important, usually occupying about 40% of the total crop acreage and having about one-third of the farm value of all the field crops. About 70% of the wheat produced in Canada is exported, 15% goes to supply Canadians with food, and the remainder is needed on the farms for seed and feed. Oats rank second in importance to wheat, occupying about one-quarter of the total acreage of field crops, but most of this crop is farm used, exports varying with production and market demand, but averaging only about 5% of the grain threshed from 1921 to 1935.

Hay crops usually occupy rather less than one-fifth of the total area of field crops, and these are used almost entirely for feeding farm animals. The acreage of barley varies considerably, but has averaged about 7% of the total crop acreage since 1921. About one-fifth of the barley is exported. Many other crops have local importance, but occupy only a small proportion of the total area.

The combined farm value of all field crops since 1921 has amounted to 61% of the gross agricultural production of the Dominion. For the first ten years of this period the value of these crops averaged about 990 millions of dollars annually, but from 1931 to 1935 the average value per year was less than one-half of this amount although the average total acreages per year were approximately equal.

Dairy products of all classes accounted for about 18% of the gross value of Canadian agricultural production from 1921 to 1935. During the second five-year period (1926 to 1930) they averaged 286 million dollars per year, but were worth somewhat less than two-thirds of this amount from 1931 to 1935.

Farm livestock made up about 10% of the gross agricultural production from 1921 to 1935. The annual averages were highest from 1926 to 1930, amounting to 187 millions of dollars per year, but dropped quickly to approximately one-half of this amount for the five years 1931 to 1935.

The revenues from poultry flocks make important supplementary contributions to farm incomes in most of the Canadian provinces, averaging about 5% of the gross agricultural production. The highest amounts were obtained from poultry from 1926 to 1930, when they averaged 98 million dollars per year,—which was 55% greater than from 1921 to 1925. They,

shrank to about 46 million dollars per year from 1931 to 1935,—a decrease of 53% from the preceding five years.

Fruit and vegetables represent about 3% of the value of the gross agricultural production of Canada. Such commodities were valued at 54 million dollars per year from 1921 to 1925, but averaged 13% less for the next five years, and dropped another 13% in value from 1931 to 1936.

Table 3 presents a summary of the gross agricultural production of Canada by provinces and by classes of commodities from 1921 to 1925.

TABLE 3.—GROSS AGRICULTURAL PRODUCTION OF CANADA—BY PROVINCES, AVERAGES PER YEAR IN MILLIONS OF DOLLARS

Provinces	Averages per year—millions of dollars				Per cent of average of 15 years, 1921 to 1935		
	1921 to 1925	1926 to 1930	1931 to 1935	1921 to 1935	1921 to 1925	1926 to 1930	1931 to 1935
Maritimes:							
Prince Edward Island	19.83	23.11	11.94	18.29	108	126	65
Nova Scotia	46.19	41.75	24.49	37.47	123	112	65
New Brunswick	40.19	36.43	22.88	33.17	121	110	69
Total	106.21	101.29	59.31	88.93	119	114	67
Central:							
Quebec	278.10	290.55	159.08	242.58	115	120	66
Ontario	441.75	494.29	287.77	407.93	108	121	71
Total	719.85	784.84	446.85	650.51	111	121	69
Prairie:							
Manitoba	120.28	127.17	57.01	101.49	119	125	56
Saskatchewan	325.02	334.74	126.20	261.98	124	128	48
Alberta	174.03	250.10	134.93	186.36	93	134	72
Total	619.33	712.01	318.14	549.83	113	129	58
Pacific:							
British Columbia	43.45	50.99	34.75	43.06	101	118	81
Dominion Total	1488.84	1649.13	859.05	1332.33	112	124	64

—	Averages per year(1)			Percent of total		
	1921 to 1925	1926 to 1930	1931 to 1935	1921 to 1925	1926 to 1930	1931 to 1935
Field crops	977.3	1002.9	479.6	65.7	60.8	55.8
Farm animals sold	137.9	186.8	94.1	9.3	11.3	10.9
Wool	3.4	4.0	1.8	0.2	0.2	0.2
Dairy products	235.6	286.3	179.3	15.8	17.4	20.9
Fruit and vegetables	53.5	46.7	39.7	3.6	2.8	4.6
Poultry and eggs	63.2	98.2	46.5	4.2	6.0	5.4
Fur farming	2.4	5.2	3.9	0.2	0.3	0.5
Other	15.5	19.0	14.2	1.0	1.2	1.6
Total	1488.8	1649.1	859.1	100.0	100.0	100.0

(1) Based on data in March issues of Monthly Bulletins of Agricultural Statistics, Ottawa.

CHANGES IN CANADIAN FARMING

Many of the changes which have taken place on Canadian farms fail to show in our statistics. Others are reported only in the decennial census, consequently cannot be studied conveniently for shorter terms.

Numbers and Sizes of Farms

The Federal Census reports show that the number of farms in Canada continued to increase during the ten years from 1921 to 1931, but at a rate of only 2.5% compared with 4.2% during the preceding decade. These increases were all in the West. In all the provinces of the maritime and central groups decreases were recorded in the numbers of farms in both census periods since 1911. During the years 1911 to 1921, the decrease was 7.0% of the number at the beginning of the period, and from 1921 to 1931, 4.6%. The greatest percentage decrease was in Nova Scotia, where the number of farms dropped by approximately one-quarter from 1911 to 1931. In the three maritime provinces, the number of farms decreased 17.3% during these 20 years, and the area included in farms decreased 12.3%. In Quebec and Ontario, the decrease in the number of farms from 1911 to 1931 was 10.3%, but during this period the area in farms actually increased by 7.4%.

The situation was quite different in the western provinces, for in the prairie and Pacific groups increases were reported in both the numbers of farms, and in the area included in them. From 1911 to 1915, extensive settlement of new lands was in progress, which slowed up as the Crown lands thought to be suitable for farming were taken up. From 1911 to 1921, 56,454 new farms were added to the prairie provinces, an increase of 28%. During the next 10 years a further increase of 32,422 farms was recorded, an increase of about 13% in number, while the area they included increased by 25%. Most of these increases were in Saskatchewan and Alberta. Similar increases were experienced in British Columbia.

In all provinces the average sizes of the farms increased from 1921 to 1931, the increase for the Dominion averaging 13.4%. During this period the increases in the west more than offset the decreases in the east, and there was a net increase in the area in farms of 16.1%. The improved area in Canadian farms increased by 21.2% during this period, and the improved area per farm by 18.3%.

Farm Tenure

A large proportion of Canadian farms are operated by their owners. In the maritime provinces and in Quebec over 95% of the total acreage is owner-operated, and in Ontario the proportion is only slightly less. About 30% of the land in farms in the three prairie provinces is rented, and in British Columbia about 20%, but these figures probably reflect the extensive areas leased for ranching. The portion of the total farm area in rented farms has increased somewhat since 1931, as the difficult conditions which have been experienced have induced some of the nominal owners, whose equities in their properties had disappeared, to surrender title to their farms and continue their operations in a changed tenure, as tenants of their former creditors.

Farm Crops

A statement of the total area of field crops in Canada, by provinces and regions, for the three five-year periods from 1921 to 1935, appeared

in Table 1. In the maritime and central groups there was comparative stability in the area used for field crops from 1921 to 1930, but for the next five years, the acreages averaged about 14% lower. The prairie group showed an increase in the field crop acreage from 1921 to 1930 of about 6%, but this was partially offset by decreases in 1933 and 1934. Substantial contractions of the field crop acreage were made in Manitoba; Saskatchewan showed relatively little change, but fairly considerable increases were reported in Alberta. In British Columbia, a slight increase in the acreage used for field crops has persisted throughout the 15 years.

Table 4 reports the average annual acreages of the most important field crops of Canada for the three 5-year periods since 1921, and also the percentage of the total crop acreage which these crops occupy.

TABLE 4.—ACRES OF FIELD CROPS IN CANADA[1]

—	Average acreage per year			Per cent of total crop acreage		
	1921 to 1925	1926 to 1930	1931 to 1935	1921 to 1925	1926 to 1930	1931 to 1935
Wheat	22.0	23.8	25.3	38.6	40.3	43.8
Oats	14.5	13.0	13.4	25.5	22.0	23.2
Barley	3.0	4.7	3.7	5.3	8.0	6.4
Rye	1.4	1.0	0.7	2.5	1.7	1.2
Mixed grains	10.8	1.1	1.2	1.4	1.9	2.1
Flaxseed	0.8	0.5	0.4	1.4	0.8	0.7
Grain hay	1.8	1.7	1.6	3.2	2.9	2.8
Peas and beans	0.2	0.2	0.2	0.4	0.3	0.3
Buckwheat	0.4	0.5	0.4	0.7	0.9	0.7
Corn for grain	0.3	0.2	0.2	0.5	0.3	0.3
Corn for fodder	0.6	0.4	0.4	1.0	0.7	0.7
Potatoes, miscellaneous roots	0.8	0.8	0.8	1.4	1.4	1.4
Clover and alfalfa	10.3	11.1	9.5	18.1	18.8	16.4
Total	56.9	59.0	57.8	100.0	100.0	100.0
Total value millions of dollars	977.4	1002.8	479.6			

[1] Data from January issues of "Monthly Bulletin of Agricultural Statistics," and Canada Year Books.

When the areas of the important crops are studied, some of the recent adjustments in Canadian agriculture are disclosed. The maximum area of wheat was reported in 1932, which coincided with the lowest level of wheat prices, but the following three years showed a reduction of about 9% in wheat acreage. This reduction is largely accounted for by the severe drought of recent years in the prairie provinces. The continuing large surpluses of wheat in store, combined with other factors to depress the market, and harass the Canadian wheat producers. Outside the prairie provinces the acreage in wheat declined, as wheat is relatively unimportant and there is little difficulty in finding an alternative to wheat production. On the prairies however, little choice is permitted, and as much wheat is grown as possible, wheat being the crop offering the best financial returns. For much of this territory, wheat is decidedly the most efficient utilizer of the erratic and scanty moisture supplies and the crop least subject to damage from the sustained hot winds. If conditions are unfavourable for wheat, they are usually more unsuitable for other crops,

with the possible exception of fall rye for which there has been practically no demand in recent years. In general, a reduction in wheat acreage may be reflected in an increased amount of fallow, or temporary (or permanent) disuse of the land. Attempts are being made to discover crops suitable for these difficult conditions, as the dangers of removal of much of the surface layers of the agricultural lands through wind erosion have been intensified during recent years, and abandonments of farms have been increasingly significant.

Since 1921, the acreage of oats has steadily decreased in all provinces of Canada excepting Saskatchewan, Alberta and British Columbia. The average acreage of oats for Canada as a whole, from 1931 to 1935, was about 7.7% lower than from 1921 to 1925. From 1926 to 1930, the average acreage per year was 11.1% below that of the preceding five years. Increases in acreages in Saskatchewan and Alberta have been fairly substantial since 1929, and in British Columbia the increase has been practically continuous since 1921. Alberta is responsible for most of the increase in the oat acreage of Canada since 1930, the oat acreage of that province from 1931 to 1935 averaging 2.8 million acres per year, or about 26% more than in the five years immediately preceding. The reduction of exports, the increasing mechanization of city draying and transfer facilities, and the greater use of tractors and trucks on farms are probably responsible for much of the reduction of the Canadian oat acreage. The increase in the acreage of wheat has been about three times as great as the reduction in the acreage of oats.

Barley ranks as the third grain crop of Canada in acreage, occupying about 4% of the total area used for field crops, but the area planted to this crop varies considerably. The acreage of barley in Canada increased from about 2.8 millions in 1921 to 5.9 millions in 1929, since when it has been reduced about 37%. In the maritime provinces there is a relatively stable acreage of barley occupying about 1% of the total area of field crops. In the central provinces of Quebec and Ontario, about 4% of the area in field crops is used for barley. Since 1921 the acreage of barley has decreased steadily in Quebec, but in Ontario it was approximately stable from 1921 to 1926, then increased until 1929, and decreased thereafter. Manitoba and Saskatchewan reported increases from 1921 to 1929, followed by substantial decreases, but Alberta has shown practically continuous increases in barley acreages since 1921. About 7.7% of the area of field crops in the prairie provinces is occupied by barley. British Columbia has a small acreage of barley, but this has been increasing steadily since 1925.

The maximum acres of rye in Canada during the last five years was in 1922, when 2.1 million acres were reported. By 1925, the acreage had been reduced to 0.6 million acres, but it increased again slowly until there was an area of 1.18 million acres in 1930. The acreage decreased in 1931 to about 0.8 million acres and has been relatively stable since that time. Practically all the rye produced in Canada is grown in the prairie provinces, where it occupies about 1.5 per cent of the total acreage of field crops. Both spring and fall varieties are grown, but about three-quarters of the total acreage is fall rye.

Flaxseed production in Canada has been mostly confined to the prairies. It was important when the prairies were being settled as it yielded well on new breaking. The maximum area of flax reported in Canada was

in 1912, when two million acres were grown. The acreages have fluctuated widely from year to year. By 1915 it was less than half a million acres, but by 1920 it had increased again to 1.4 million acres. It then decreased from 1921 to 1923 to approximately the low level of 1915, then doubled in 1924, decreasing thereafter to new low levels. Since 1926 production has been insufficient for Canadian needs.

Hay crops other than grain occupy about 10% of Canadian field crop acreages. They are very important in the farm organizations of the maritime and central groups, where about one-half of the total field crop acreage is used for hay. Some reductions in the acreages of hay crops have been made since 1930. In the prairie provinces conditions are not usually favourable for hay crops and they occupy only about 3% of the total field crop area.

FARM ANIMALS

Horses

In June, 1935, there were about 2.9 million horses of all ages in Canada, a slight decrease from a year earlier. The number of colts on farms is now increasing and probably the low point in the horse population of Canada will soon be reached. With the exception of British Columbia, all provinces report decreases, which have continued steadily since 1921. There is usually a small export trade in good heavy horses from the Dominion.

Cattle

Since 1921, the average number of cattle in Canada has been about nine millions, of which 3.7 millions are classed as "milch cows" in the Dominion reports and 5.3 millions as "other cattle." The high points in the numbers of milch cows were in 1927, with 3.9 millions, and eight years later in 1935 with 3.85 millions. The intervening low point was in 1931, when 3.4 millions were reported. The spread between these extremes amounted to 13.7% of the average of the last 15 years. Other cattle experienced wider variations in numbers, which amounted to 35.3% of the 15-year average, being highest in 1921, and lowest ten years later.

About 60% of the milch cows are in Ontario and Quebec, 8% in the maritime provinces and 2% in British Columbia. The dairy industry showed the greatest degree of stability in Quebec and Ontario, judging by the numbers of milch cows, which varied by only 18% of the 15-year average from the high point in 1927 to the low of 1932. Elsewhere the variation was about 30% or greater. The difficulties attending the drought conditions in the prairie provinces almost completely disorganized the cattle industry during recent years. The agricultural adjustment policies of the United States, coupled with drought, raised prices sufficiently to attract substantial quantities of Canadian cattle over the three-cent tariff barrier in 1935, and relieved the British markets of our modest contributions to their supply of beef.

Sheep

During the past 15 years, the average number of sheep in Canada was about 3.2 millions, the greatest numbers being in 1921 and 1930, when about 3.7 millions were reported. Decreases occurred from 1921 to 1924, amounting to about 30% of the 15-year average, but a full recovery was made by 1930, following which small decreases were again experienced.

In the maritime provinces sheep have been steadily decreasing in numbers since 1921, the latest estimates amounting to only 42% of those of that year. Statistics for Quebec indicate an almost continuous reduction of sheep during the last 15 years, the number in 1935 being only two-thirds of that of 1921. In Ontario the number of sheep has also been declining since 1921, the total decrease amounting to about 12% of the number reported at that time.

In the prairie provinces sheep are found in small flocks on a limited number of farms, and in fairly large flocks in the few areas where range is available. Numbers of sheep have fluctuated considerably since 1921, but the net result has been an increase of about 56% in the sheep population during the past 15 years. On the Pacific coast, the province of British Columbia reported steadily increasing numbers of sheep from 1921 to 1929, with a recession of two years followed by further increases from 1932 to 1935.

There is no significant export of sheep or lambs from the Dominion, and the amount of wool produced is less than is required by the Canadian industries.

Swine

During the past 15 years the swine population of the Dominion has averaged around 4.26 millions, being highest in 1924 with 5.07 millions, and lowest in 1935 with 3.55 millions. It is characteristic of this class of stock to exhibit rapid fluctuations in numbers in Canada, particularly in the prairie provinces. The general trend has been downwards, but the adjustments have varied with the regions influenced by the kind and degree of the many factors affecting this industry. Since 1930 exports of the different forms of swine products have been equivalent to around 8% of the total supply.

In the maritime provinces, numbers of hogs declined 17% from 1921 to 1923, moved irregularly higher to regain the loss during the next five years, reached a record number in 1932, to drop again to the lowest point in 1934. Probably the greatest stability in this class of livestock is found in Ontario and Quebec, where it forms an important and permanent part of the farm organization. From 1921 to 1930 there was relatively little variation in the numbers of pigs reported in these two provinces, but during the last five years numbers have ranged about 25% lower than those of the previous decade.

The situation in the prairie provinces has been an extremely variable one. Manitoba shows the number of swine comparatively stable, but Saskatchewan and Alberta reports wide fluctuations resulting from the violent changes in feed conditions from year to year, and from extreme movements of prices of market hogs. The average of the 15 years for these two provinces is 1.45 millions, but the variations have been frequent and wide ranging from 1.01 in 1921 to 1.82 millions in 1924. In British Columbia numbers of pigs increased steadily from 1921 to 1930, but declined thereafter to 1934.

Poultry

Statistics relating to poultry on farms indicate increasing numbers from 1921 to 1931 of about 75%, since when about one-third of the increase has been lost. The modest export trade of dressed poultry takes about 1% of the total supply.

DAIRY PRODUCTS

Accurate estimates of the total production of milk in Canada are not obtainable, nor are they available for the amounts needed for market milk purposes by Canadians. It is reasonable to consider that about 40% of the total production is required for market milk trade. From about 45% of the total supply comes the cream for butter making, two-thirds of which goes to the creameries. Cheese making requires about 10% of the supply, most of which comes from Ontario and Quebec, and is factory made. These two provinces also produce the major portion of the butter made in Canada, amounting to 64% of the total, while the production of the prairie provinces accounts for about 29%. Small amounts of butter are occasionally exported from Canada, but the Dominion is usually on a net import

TABLE 6.—AVERAGE ANNUAL PRODUCTION OF DAIRY PRODUCTS IN CANADA(1)

—	1921 to 1925		1926 to 1930		1931 to 1934	
	Millions of pounds	Millions of dollars	Millions of pounds	Millions of dollars	Millions of pounds	Millions of dollars
BUTTER:						
Dairy	100.0(2)	32.1	93.1	28.8	106.6	17.7
Creamery	158.5	56.4	175.8	63.0	223.1	45.1
Total	258.5(2)	88.5	268.9	91.8	329.7	62.8
		Cents per pound		Cents per pound		Cents per pound
Average value:						
Dairy	–	32.0	–	30.9	–	16.6
Creamery	–	35.6	–	35.8	–	20.2
All butter	–	34.2	–	34.1	–	19.1
		Millions of dollars		Millions of dollars		Millions of dollars
CHEESE:						
Farm	0.5	0.1	0.5	0.1	1.0	0.1
Factory	155.3	28.0	138.4	24.9	111.4	11.3
Total	155.8	28.1	138.9	25.0	112.4	11.4
		Cents per pound		Cents per pound		Cents per pound
Average value:						
Farm	–	17.0	–	14.4	–	9.1
Factory	–	18.0	–	18.0	–	10.1
		Millions of dollars		Millions of dollars		Millions of dollars
Miscellaneous manufactured products	–	16.9(2)	–	20.1	–	14.6
Milk used otherwise	–	136.2(2)	–	140.4	–	78.4
Total value of all dairy production	–	285.0	–	279.7	–	175.8

(1) Data from Canada Year Books.
(2) Statistics incomplete, estimated from data available.

basis of 1 or 2%. About two-thirds of the cheese produced is exported, most of which goes to Britain.

Since 1921 the amount of milk produced in Canada has been steadily increasing. The annual make of butter has increased by over one-third during these 15 years, much of which is offset by the reduction in cheese production. The amount needed for the fluid milk trade has also shown steady increase.

Table 6 summarises data from official sources relating to the production of dairy products.

THE SITUATION OF THE WHEAT PRODUCERS

No appraisal of the effects of the recent crop failures and general economic disorganizations on Canadian agriculture can be attempted in this paper, but some indications of the difficulties which continue to beset Western Canada must be included. The remaining sections deal with the condition of agriculture in the prairie provinces, which is one of the most important factors in the economic life of Canada, and vitally associated with the welfare of the Dominion as a whole. The prosperity of agriculture in Western Canada is dependent on the wheat crop, its physical production and the amount for which it sells at the local shipping points. For many farmers the revenues from wheat sales are the only ones of significance, and when these fail there is nothing available on the farm to help out the situation. The preceding discussions of the gross agricultural revenues of the various sections of Canada gave general consideration to this subject. The specific application to the wheat growers, and to the revenues from wheat growing operations is now presented to supplement the earlier information.

Table 7 summarises information on the production and sales of wheat in Canada.

The statistician will appreciate the facts contained in this table. The sociologist would find in the situation represented ample scope for developing his story, replete with human interest and overloaded with discouragement.

The hazards of wheat production are many and serious, and yields vary unmercifully from district to district, and from year to year. The fluctuations in market prices throughout this period, and the variations in the grades produced are further disturbing factors in a most complicated situation. With a comparatively brief agricultural history, in which each year seems radically different from every other, the determination of the "normal" is a thankless task, and the forecasts of production subject to very grave error. For the individual farmer whose location is not better than the average of the province, the uncertainty is even greater than for the district as a whole, on account of the many things beyond his control that may happen over very restricted areas to aid him or to thwart his efforts. The recent prolonged sieges of drought, grasshoppers, rust, etc., have been widespread, however, and have blasted the grain crops over very extensive areas. Not long ago a prominent administrator aptly described the agriculture of a large part of Saskatchewan "as a series of emergencies." There are, however, considerable areas of Saskatchewan for which the crop histories are extremely good, the farmers of which have been particularly fortunate.

TABLE 7.—SUMMARY OF STATISTICS OF WHEAT PRODUCTION AND SALES IN CANADA, 1921 TO 1935([1])

——	Average per year					
	Area millions of acres	Total yield millions of bushels	Yield per acre in bushels	Total value millions of dollars	Value of wheat sold: Cents per bushel	Value of wheat sold: Dollars per acre ([2])
CANADA:						
1921 – 1925	22.2	366.5	16.5	341.5	93	13.93
1926 – 1930	23.9	431.2	18.0	373.2	87	14.37
1931 – 1935	25.9	319.9	12.5	151.0	47	5.18
Average—15 years	23.9	372.5	15.6	288.5	77	10.85
TOTAL PRAIRIES:						
1921 – 1925	21.2	342.1	16.2	312.8	91	13.33
1926 – 1930	22.9	407.2	17.8	345.1	85	13.82
1931 – 1935	24.8	302.1	12.2	139.1	46	4.93
Average—15 years	23.0	350.5	15.3	265.7	76	10.47
MANITOBA:						
1921 – 1925	2.8	41.4	14.9	39.9	96	12.85
1926 – 1930	2.3	40.8	17.4	37.1	91	14.50
1931 – 1935	2.6	32.9	12.7	16.5	50	5.61
Average—15 years	2.6	38.4	14.9	31.2	81	10.88
SASKATCHEWAN:						
1921 – 1925	12.8	211.9	16.5	195.0	92	13.79
1926 – 1930	13.8	230.1	16.6	195.5	85	12.88
1931 – 1935	14.4	144.2	10.1	67.1	46	3.93
Average—15 years	13.7	195.4	14.3	152.5	78	9.98
ALBERTA.						
1921 – 1925	5.6	88.8	16.0	77.9	88	12.75
1926 – 1930	6.8	136.3	20.2	112.5	84	13.48
1931 – 1935	7.8	125.0	16.0	15.5	44	6.38
Average—15 years	6.7	116.7	17.4	82.0	70	11.12

([1]) Based on data reported in the January issues of the Monthly Bulletin of Agricultural Statistics, Ottawa.
([2]) Assumed 1½ bushels per acre reserved for seed and other farm uses.

From 1921 to 1928 yields of wheat were generally above the average and prices satisfactory, consequently the wheat acreage of Canada expanded. Although wheat producers had their problems, they were not insurmountable. Some districts were more frequently in distress than others, and occasionally assistance in the form of feed and seed was required but these difficulties were of a temporary character and repayment of the advances was looked for. More recently conditions have changed, and since 1928 both yields and prices of wheat in Saskatchewan have declined to about 60% of those of the preceding eight years, and thus the revenues resulting have shrunk to about one-third of the former average. The situation was somewhat less difficult in Manitoba and Alberta, but in each province the cause of very grave distress.

Troubles began to be acute in Saskatchewan in 1929, when the south central portion experienced so serious a crop failure from drought that the

provision of farm relief on a large scale was unavoidable. These conditions extended and intensified during the next five years, with grasshoppers adding to the difficulties; consequently much of the agricultural area became dependent on the governments, the distribution of relief becoming their principal agricultural undertaking. A promising crop was indicated in 1935, but this became a failure through rust. Prospects were again excellent in June of this year, but the relentless heat that followed has taken another heavy toll over much of the province and farm relief will again be necessary on a considerable scale.

The prolonged difficulties in southern Saskatchewan, and in other parts where similar results have been experienced, have caused many farmers to abandon their lands, and move to the wooded areas on the northern fringe of settlement. Government assistance has also been necessary in these new locations, many of which are totally unsuitable for agricultural development.

CONCLUSION

How then have the farmers of Canada adjusted their businesses to the difficult conditions of recent years? The methods followed have varied with the regions, but have been generally of a conservative nature, with the objective of holding the businesses together until times improve.

In the older areas of eastern Canada, the adjustments have been moderate, and in keeping with the permanent character of their farming. There have been some combinations of farms, some reductions in the areas included in farms, small decreases in the acreages of field crops, and some contractions of animal enterprises. Farm lands have dropped in value, farm labour has had to take lower wages, and more of the work has been done by family labour. Farm capital of all classes has deteriorated, and reduced outlays for many of the usual items of farm operation have been unavoidable. The problem of farm debt has grown and the provision of considerable farm relief has been necessary in many areas where formerly such advances were unknown. Reserves of all kinds have been drawn on, generally to the limit, and in many cases have long been exhausted.

Farmers of Western Canada have scarcely been able to undertake anything constructive in their adjustments during recent years. For the most part, they have been waging a war with the forces of nature to try to carry on, and to salvage something of their farms. In extreme cases the only course available has been the abandonment of the farms and removal to another settlement. Since 1929, on the basis of studies made by the University of Saskatchewan, it is estimated that the farm equipment of this province has suffered a cumulative deterioration of at least 50%. Buildings, fences, and in many cases even the lands used for cultivation have also deteriorated heavily. Reserves of feeds and supplies have been exhausted, and much is needed to make up for the drains of the years of poor crops. In the farm homes household equipment, furnishings, and clothing, and even the people of the farm, bear pathetic testimony to the depleted revenues. In common with neighbours across the international boundary they have suffered severely. The powers of recuperation of the country and the people are great, and Western Canada is frequently termed a "next year" country, but probably nothing has proved quite so discourag-

ing for many on prairie farms as seeing the present crop deteriorate, from which so much had been expected. Many problems remain to be solved, but much fundamental knowledge must be gained before satisfactory solutions are possible. They may provide interest for future sessions of this Conference.

Résumé

Remaniements récents de l'organisation agricole au Canada. Wm. Allen, Université de Saskatchewan, Saskatoon, Sask.

Les méthodes adoptées par les cultivateurs canadiens pour résister à la crise de ces dernières années variaient suivant les régions; elles étaient en général d'une nature conservatrice, tendant à maintenir l'exploitation en attendant que la situation s'améliore. Dans les régions les plus anciennes de l'est du Canada les remaniements ont été modérés, s'accordant avec la nature permanente de l'exploitation agricole. On a réuni quelques fermes en une seule, ou réduit leur étendue, réduit légèrement l'étendue consacrée aux récoltes de grande culture et la production animale. La valeur des terres arables a baissé, la main-d'œuvre agricole a dû accepter une réduction de salaire; elle a été remplacée dans une certaine mesure par la famille du cultivateur. Le capital agricole de toutes les catégories s'est amoindri et il a fallu nécessairement réduire les déboursés sur beaucoup des item ordinaires de l'exploitation agricole. Le problème des dettes s'est aggravé et l'assistance publique a dû intervenir dans bien des régions dont elle n'avait pas à s'occuper autrefois. On a dû tirer sur les réserves de tous genres, généralement jusqu'à la limite, et ces réserves sont depuis longtemps épuisées sur bien des fermes. Les cultivateurs de l'ouest du Canada n'ont pu faire que peu ou point d'améliorations foncières en ces dernières années. La plupart d'entre eux ont lutté contre les forces de la nature pour se maintenir et sauver quelque chose de leurs fermes. Dans des cas extrêmes ils n'ont eu d'autre alternative que d'abandonner leur ferme et de se transporter ailleurs. Depuis 1929, on estime, en se basant sur une enquête conduite par l'université de Saskatchewan, que le matériel agricole de cette province a subi une détérioration cumulative d'au moins 50%. Les bâtiments, les clôtures et même, dans bien des cas, la terre arable, se sont grandement détériorés. Les réserves d'aliments et de provisions ont été épuisées, et bien des choses seraient nécessaires pour combler les vides laissés par les années de mauvaises récoltes. Dans les maisons de ferme, les ustensiles de ménage, les meubles, les vêtements et les gens eux-mêmes offrent un témoignage pathétique de la disparition du revenu. Ils ont beaucoup souffert, de même que leurs voisins de l'autre côté de la frontière. Sans doute le pays et la population ont une grande puissance de redressement, et on a souvent dit que l'ouest du Canada est le "pays de l'année qui vient", mais rien peut-être n'a causé un tel découragement parmi les cultivateurs des Prairies que de voir la récolte actuelle, sur laquelle on fondait tant d'expoirs, se détériorer. Il reste encore bien des problèmes à résoudre mais il faudra acquérir bien des connaissances fondamentales avant que l'on puisse trouver une solution satisfaisante. Ces questions seront sans doute l'objet des discussions animées aux séances futures de cette conférence.

INHERITANCE OF EARLINESS OF HEADING AND OTHER CHARACTERS IN A GARNET × RED FIFE CROSS[1]

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INTRODUCTION

The importance of early varieties of cereals to the Canadian farmer cannot be overestimated. Newman (21) states that the occurrence of late summer frosts in many districts of the West has made the use of early maturing varieties almost obligatory. It is for this reason that a knowledge of the mode of inheritance of earliness is of great importance and should enable one to choose parents that will give progenies of larger numbers of early plants in proportion to the late ones. It is also of great value to know whether one can select with success for a particular character during early generations. Furthermore, it is always advisable to ascertain whether such foremost characters are inherited independent of other agronomic characters, such as awns and disease. This study, therefore, was contemplated for the purpose of obtaining more knowledge on the mode of inheritance of earliness and awns, and further to discover if there exists any relationship between earliness and awns, awns and bunt resistance.

MATERIALS AND METHODS

Seeds of single line selections of the early, awnletted, bunt resistant parent Garnet Ottawa 652, C.A.N. 1316; and the late, apical-awned, bunt-susceptible parent Red Fife Ottawa 17, C.A.N. 1513, both *Triticum vulgare Al.* were used to make crosses in the greenhouse during the winter of 1933–34. The bunt inocula consisted of chlamydospore collections of *Tilletia-tritici* and *T. laevis* which were procured from bunted heads of Garnet and Red Fife wheat. The inocula were reasonably pure as to species.

The parents, F_1 and F_2 were grown in the greenhouse, in 6-inch pots, with five seeds per pot during the winter of 1934–35. In the field in 1935, seeds of parents, F_1, F_2 and F_3 generations were planted on the same day, spaced three inches apart in the rows and with seven inches between rows. In most cases, 24 seeds were sown in each row.

The dates of heading in both field and greenhouse studies were based on the emergence of the topmost spikelet from their leaf sheath (11, 22), and they were recorded daily (9). The records of date of heading were attached to each plant by means of a string tag. Early, intermediate and late F_2 plants were chosen and used for F_3 studies.

Seeds that were inoculated with bunt were well shaken in an abundance of chlamydospores and all plants were considered infected that showed traces of bunt.

The classification of the awns of F_2 plants was similar to that of Clark *et al.* (7), namely: awnless, apical-awnletted, awnletted and awned. Some plants of each of these awn classes were grown in the field.

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TABLE 1.—INHERITANCE OF EARLINESS IN A GARNET × RED FIFE CROSS

—	Early										Intermediate										Late									
A. Greenhouse data, 1934–35																														
Number of days to heading	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Garnet Ottawa 652	1	1	2	2	6	6	7	4	3	2	1	2																		
F_1											1	1	10	6	5	5	5	4	1	1	2									
Red Fife Ottawa 17																				2	3	1	1	3	5	7	4	5	0	2
F_2	1	3	6	2	6	24	26	23	43	31	91	166	81	87	61	116	97	53	71	57	65	52	46	53	38	26	15	4	4	1
Number of plants in F_2 heading groups	256										789										304									

—	Early					Intermediate				Late											
B. Field data, 1935																					
Number of plants in F_2 heading groups	89					342				164											
F_2 34–44 A			1	3	15	9	23	20	13	14	2	5	4	4	1	2	0	2	3	0	1
F_2 34–45 A				4	16	11	17	10	8	7	2	5	3	0	1	0	1	1	0	1	0
F_2 34–57 A			1	4	8	26	22	19	15	14	2	3	4	3	4	0	0	0	0	1	0
F_2 34–59				1	1	5	6	10	2	2	2	2	0	2	1	1	0	0	1	0	0
$F_2$34–64			1	9	25	31	40	23	32	11	14	6	11	4	7	5	3	0	1	0	1
Red Fife Ottawa 17									1	23	17	30	20	16	6	3	6	1	1	3	1
F_1					14	10	26	4	2	5	1	3									
Garnet Ottawa 652	4	29	39	23	28	7	5	2	1												
Number of days to heading	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78

TABLE 2.—PARENT, F_1 F_2 AND F_3 DATES OF HEADING IN THE FIELD

Number of days to heading and number of plants in heading classes

Key to item	Early					Intermediate				Late												Total number of plants	Average number of days to heading and *S.E. in days
Field	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78		
Garnet Ottawa 652	4	29	39	23	28	7	5	2	1													138	60.7 ± 0.13
Red Fife Ottawa 17									1	23	17	30	20	16	6	3	6	1	1	3	1	128	69.7 ± 0.21
F_1					14	10	26	4	2	5	1	3										65	64.0 ± 0.22
Early F_2 plants																							
F_2 34–52 A–11					2	7	6	1		1	1											18	63.8 ± 0.41
34–52 B–28					3	5	2		1													11	63.1 ± 0.37
34–52 C–11			1	1	1	2	7	2	2	1												17	63.8 ± 0.43
34–52 C–14				1	2	6	3	1			1											14	63.4 ± 0.45
34–52 C–18				3	7	3	3	1	1		1											19	63.0 ± 0.42
Intermediate F_2 plants																							
F 34–52 A-17							2	3	6	5	1											17	66.0 ± 0.36
34–52 B–3						2	2	2	1		1		1	1								15	65.9 ± 0.91
34–52 B–5							6	2	1		1	1	1		1					1		14	66.8 ± 1.09
34–52 B–11							4	5	2	2												13	65.1 ± 0.91
34–52 B–14						2		2	1		1		2	1	2							11	67.7 ± 1.09
34–52 B–16					1	1		2	1	1	3			1			1		1			12	68.3 ± 1.37
34–52 B–66						1		7		2		1										11	66.2 ± 0.37
34–52 C–21					1	1	4	2		1	1	1	1		1				1	1		14	66.7 ± 1.16
Late F_2 plants																							
34–52 A–18										1	3		1		1	1	1				1	9	70.8 ± 1.34
34–52 B–7									2	3		2	2	2	1					1		13	69.4 ± 0.93
34–52 B–15										2	1	2	2	3				1		1	2	14	75.5 ± 1.05
34–52 C–30										2		1		6		5	1					15	71.2 ± 0.57

*In every case the standard error (S.E.) was calculated according to Fisher's formula $S^2 = \frac{S(x - \bar{x})^2}{N - 1}$.

INHERITANCE OF EARLINESS OF HEADING

Certain investigators of the inheritance of earliness of heading (6, 16, 17, 20, 22, 23) have revealed that almost invariably there are numerous factors involved and that a very complex segregation is most usual. Others (8, 9, 11, 17, 24) obtained with certain crosses definite mono- or dihybrid ratios. In general, there are indications that the inheritance of earliness of heading varies with different varieties of the same species as much as it does with different genera.

The parents, F_1 and F_2 were grown and studied in both greenhouse and field and it will be observed from Table 1 that the segregation was of a similar type.

It may well be said that the F_2 generations of this cross were grown in two entirely different environments and yet the gradation of the segregates remained similar; this is in accordance with the findings of Jones *et al.* (17). This uni-modal distribution of the F_2 heading dates is indicative of a very complex type of segregation involving the presence of many factors.

Table 2 illustrates that early F_3 lines may be selected in the F_2 generation and that the earliness of the Garnet parent was not recovered entirely.

AWNS AND BUNT

Several investigators (1, 5, 13, 18) have ascertained that Garnet wheat shows considerable resistance to physiologic forms of bunt, at least when compared with the susceptible parent Red Fife, (5).

It was determined by Kilduff (18) that the resistance of Garnet to bunt was governed by one main partially dominant factor, and that this factor was associated with awns. The following tables substantiate his mono-hybrid hypothesis with respect to bunt but indicate that awns are inherited independently.

TABLE 3.—F_3 LINES SEGREGATING FOR AWNS AND RESISTANCE TO THE BUNT INOCULA *T. tritici* AND *T. laevis* SCREENED THROUGH THE PARENTS AND F_2

Population numbers	Number of plants in awn classes							
	Bald		Apical awned		Awnletted		Awned	
	Resistant	Bunt	Resistant	Bunt	Resistant	Bunt	Resistant	Bunt
34–56–1	8	4	0	0	3	2	1	1
34–56–6	21	7	0	0	0	0	0	0
34–56–7	8	2	2	0	4	0	1	0
34–56–8	6	1	2	2	3	0	1	0
34–56–11	4	2	3	0	6	1	1	0
34–56–12	5	0	1	2	2	0	1	0
34–56–13	2	2	1	0	0	0	0	0
34–56–14	0	0	7	3	3	2	3	1
Total	54	18	16	7	21	5	8	2

X^2'S OF DATA PRESENTED IN TABLE 5

Bald	0.0
Apical awned	0.3617
Awnletted	0.4614
Awned	0.1333
Total	X^2 = 0.9564
	P = 0.80 to 0.90.

TABLE 4.—F_3 LINES SEGREGATING FOR AWNS AND RESISTANCE TO THE BUNT INOCULUM *T. laevis* FROM RED FIFE SCREENED THROUGH THE F_2

Population numbers	Number of plants in awn classes							
	Bald		Apical awned		Awnletted		Awned	
	Resistant	Bunt	Resistant	Bunt	Resistant	Bunt	Resistant	Bunt
34–55–1	5	1	4	1	5	4	2	1
34–55–3	5	3	3	1	0	0	0	0
34–55–4	4	1	6	1	2	1	2	1
34–55–11	4	1	2	2	6	1	2	0
34–55–16	0	0	0	0	14	3	3	1
34–56–10	11	3	4	1	0	1	0	0
34–56–12	4	4	3	1	5	0	3	1
34–56–13	14	3	2	3	2	1	0	0
34–56–26	0	0	0	0	14	4	6	3
34–56–27	0	0	0	0	0	0	19	6
Total	47	16	24	10	48	15	37	13

X^2'S OF DATA PRESENTED IN TABLE 6

Bald	0.0052
Apical awned	0.3524
Awnletted	0.0473
Awned	0.0266
Total	X^2 = 0.4315 P = 0.90 to 0.95

TABLE 5.—F_3 LINES SEGREGATING FOR AWNS AND RESISTANCE TO THE BUNT INOCULUM *T. tritici* FROM RED FIFE SCREENED THROUGH THE F_2

Population numbers	Number of plants in awn classes							
	Bald		Apical awned		Awnletted		Awned	
	Resistant	Smutted	Resistant	Smutted	Resistant	Smutted	Resistant	Smutted
34–56–3	11	2	0	0	0	1	0	0
34–56–6	5	3	3	0	2	0	1	0
34–56–7	1	0	2	1	0	0	0	0
34–56–10	8	4	0	0	0	0	0	0
34–56–11	7	0	3	2	0	2	0	0
34–56–12	9	3	0	0	1	0	0	0
34–56–13	7	3	5	0	0	0	0	0
34–56–14	3	1	6	1	1	0	2	0
34–56–15	2	0	4	1	2	2	1	0
34–56–16	8	3	3	1	2	0	1	0
34–56–17	0	0	6	1	0	0	0	0
34–56–20	2	1	2	1	0	0	0	0
34–56–22	0	0	14	5	0	0	0	0
34–56–24	3	0	6	2	3	2	3	0
34–56–25	7	3	5	0	4	1	1	0
34–56–26	1	0	2	0	3	0	2	2
34–56–28	1	0	2	1	6	2	6	3
34–56–30	0	0	0	0	0	0	6	2
Observed	75	23	63	18	24	10	23	7

X^2'S OF DATA PRESENTED IN TABLE 34

Bald	0.1224
Apical awned	0.3329
Awnletted	0.3529
Awned	0.0444
Total	X^2 = 0.8526 P = 0.80 to 0.90.

Although Tables 3, 4 and 5 embrace the study of only 36 segregating F_3 lines or a total of 584 plants, it is, however, evident that the inheritance of bunt resistance in Garnet wheat was completely independent of the awn factors. In each awn group, the segregation of the factors for bunt resistance took place in a simple 3 resistant : 1 susceptible ratio.

AWNS AND EARLINESS

The inheritance studies of awn characters may be of great economic importance since several authors obtained a correlation between thea wned character of wheat and yield Hayes (15) and Goulden and Neatby (14). On the other hand, Aamodt and Torrie (2) and Love and Chang (19) concluded that there was no association under their environmental conditions and strains of wheat investigated. In reference to the relation of awns and earliness, it was found by Biffen (3) and Gaines and Singleton (12) that these characters will recur independently. Bjaanes (4) crossed Garnet, with short awns, with two Swedish and two Norwegian varieties having short awns. In every case, the F_1 was bald, and in the F_2 new awnless (AABB) and awned (aabb) types appeared; he concluded, therefore, that Garnet carried an inhibiting factor for baldness. Kilduff (18) working with a Garnet × Kota cross arrived at the conclusion that there was probably more than one factor involved in awn segregation of these hybrids.

TABLE 6.—GOODNESS OF FIT OF AWN SEGREGATION IN 3 F_2 FAMILIES GROWN IN THE GREENHOUSE IN 1934–35

——	Observed	Calculated		(O − C)	$(O-C)^2$	$\frac{(O-C)^2}{C}$
Awnless	149	150.62	(5)	1.62	2.62	0.0173
Apical awned	151	150.62	(5)	0.38	0.14	0.0002
Awnletted	154	150.62	(5)	3.38	11.49	0.0762
Awned	28	30.14	(1)	2.14	4.57	0.1516
Total	482	482.00		$X^2 = 0.2453$		

Exceedingly good fit, for P = 0.95 to 0.98.

TABLE 7.—GOODNESS OF FIT OF AWN SEGREGATION IN 4 F_2 FAMILIES GROWN IN THE FIELD IN 1935

——	Observed	Calculated		(O − C)	$(O-C)^2$	$\frac{(O-C)^2}{C}$
Awnless	64	63.13	(5)	0.87	0.75	0.0137
Apical awned	63	63.13	(5)	0.13	0.16	0.0020
Awnletted	64	63.13	(5)	0.87	0.75	0.0137
Awned	11	12.61	(1)	1.61	2.59	0.2053
Total	202	202.00		$X^2 = 0.2347$		

Exceedingly good fit, for P = 0.95 to 0.98.

From Tables 6 and 7 it may be seen that a two factor hypothesis giving a 5 awnless : 5 apical awned : 5 awnletted : 1 awned gave a good agreement in both the greenhouse and field grown populations (4).

TABLE 8.—X^2 TEST OF TRUE BREEDING AND SEGREGATING F_3 LINES THAT COME FROM F_2 FAMILIES

——	Observed	Calculated	(O − C)	$(O - C)^2$	$\frac{(O - C)^2}{C}$
Awnless	5	3	2	4	1.3333
Apical awned	3	3	0	0	0.0
Awnletted	4	3	1	1	0.3333
Awned	3	3	0	0	0.0
Segregating	33	36	3	9	0.25
Total	48	48	$X^2 = 1.9166$		

A very good fit for P = 0.7 to 0.8.

According to the data presented in Tables 6, 7 and 8, the phenotypes of the parents, F_1 and F_2 are as follows:—

Awnletted parent Garnet $B_1B_1b_2b_2$ × Apical awnletted Red Fife $b_1b_1B_2B_2$
F_1 Awnless $B_1b_1B_2b_2$

F_2 genotypes	F_3 breeding behaviour			
	Bald	Apical awned	Awnletted	Awned
Bald (5)				
1 $B_1B_1B_2B_2$	1	0	0	0
4 $B_1b_1B_2b_2$	5	5	5	1
Apical (5)				
2 $B_1b_1B_2B_2$	1	3	0	0
1 $b_1b_1B_2B_2$	0	1	0	1
2 $b_1b_1B_2b_2$	0	3	0	1
Awnletted (5)				
2 $B_1B_1B_2b_2$	1	0	3	0
1 $B_1B_1b_2b_2$	0	0	1	0
2 $B_1b_1b_2b_2$	0	0	3	1
Awned (1)				
1 $b_1b_1b_2b_2$	0	0	0	1

In Table 9, a number of F_3 lines, composed of twenty plants in each awn class and heading date groupings, are presented. The evidence presented in this table shows that earliness of heading in wheat may be obtained in all awn classes (3, 12).

For every 16 F_2 plants 4 pure breeding F_3 lines and 12 segregating F_3 lines were expected on the basis of awn types. The correctness of this assumption was given by the use of the X^2 test in Table 8.

After these data were analysed, it was observed that Bjaanes (4) claimed that Garnet carried one inhibitor for baldness. The author's results showed that the factors were cumulative and inhibited the expression of awns. The factors B_1 of Garnet and B_2 of Red Fife were non-allelomorphic, acted as inhibitors of awns, B_2 being more powerful than B_1. Actually the awns of the Garnet parent were softer in texture than those of Red Fife wheat.

TABLE 9.—CLASSIFICATION OF F_2 PLANTS AND F_3 LINES WITH RESPECT TO EARLINESS OF HEADING IN DIFFERENT AWN CLASSES

Population Nos.	Classification of F_2 plants in greenhouse	F_3 behaviour	
		Awn class	Average number of days to heading in the field and S.E. in days
34–52 B1–4	Early	Bald	65.7 ± 0.81
34–52 B12–14	Intermediate	Bald	67.4 ± 0.60
34–53 B17–20	Late	Bald	68.8 ± 0.81
34–52 B21–22	Apical awns	Apical awns	65.7 ± 0.61
34–52 B37–39	Intermediate	Apical awns	67.6 ± 0.91
34–52 B43–45	Late	Apical awns	70.4 ± 0.97
34–52 B46–49	Early	Awnlet	64.2 ± 0.73
34–52 B61–63	Intermediate	Awnlet	66.8 ± 0.72
34–52 B67–68	Late	Awnlet	68.0 ± 0.51
34–52 B18	Early	Awned	62.0 ± 0.32
34–52 B72–74	Intermediate	Awned	67.6 ± 0.66
34–52 B75	Late	Awned	67.7 ± 0.73

DISCUSSION

It was of great interest to note from Table 1, that F_2 populations grown in the greenhouse under artificial conditions gave a similar segregation as those grown under normal field conditions. These data prove conclusively that environment does influence the length of time it takes for emergence, but it failed in this case to disturb the relationship of the genotypes as observed from the phenotypic expressions.

From this study with Garnet and Red Fife, it was also established that any awn type may be suitable with respect to earliness and bunt resistance. If it should be the case that, due to certain physiological reasons, a certain awn type would be preferable from a general agronomic aspect, one will at least be assured that neither earliness nor bunt resistance need be sacrificed.

The rather peculiar ratio of 5 awnless : 5 apical awned : 5 awnletted : 1 awned is of great interest, since two entirely new types occurred, one completely awnless and the other with awns. The factors B_1B_1 present in Garnet inhibit complete awn development, while B_2B_2 of Red Fife inhibit awns except for short tip awns. If B_1B_1 and B_2B_2 were balanced, a bald spike was obtained, a balance offset in favour of B_1 resulted in an awnletted spike, and that in favour of B_2 resulted in apical awns; the absence of both B_1B_1 and B_2B_2 gave an awned spike.

SUMMARY

1. The F_1 of a cross between the early parent Garnet and the late parent Red Fife was found to be intermediate in respect of earliness. The F_2 segregation was of a uni-modal distribution in the greenhouse as well as in the field. The presence of the action of many factors governing earliness was evident. The selection of early F_3 lines based on the F_2 behaviour was possible, but the parent earliness was not recovered.

2. The inheritance of bunt resistance in a Garnet cross was governed by a single main factor. It was found that bunt resistance in Garnet wheat was not linked with the awn factors.

3. The awn segregation in the F_2 and F_3 was in the dihybrid ratio of 5 awnless : 5 : apical awned : 5 awnletted : 1 awned. The parents carried different factors for awnlessness which behaved cumulatively in inhibiting the expression of awns. Inheritance of earliness and awns appeared independent since early, intermediate and late F_3 lines were obtained in each awn class.

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Résumé

Transmission héréditaire de l'épiage précoce et d'autres caractères dans un croisement de Garnet X Fife rouge. F. Gfeller, Ferme expérimentale centrale, Ottawa, Canada.

Il a été constaté que le F1 d'un croisement entre le parent hâtif Garnet et le parent tardif Fife rouge est intermédiaire en ce qui concerne la précocité, tandis que la ségrégation de F2, dans la serre et dans le champ, donnait la proportion relative que voici: 9 intermédiaires: 3 hâtifs: 4 tardifs. La période d'épiage du parent et des hybrides tardifs s'est prolongée sur un nombre uniforme de jours, dans le champ comme dans la serre, tandis que le parent hâtif raccourcissait sa période d'épiage dans le champ. La transmission héréditaire de la résistance à la carie dans un croisement de Garnet était sous la dominance d'un seul facteur principal. On a constaté que la résistance à la carie dans le blé Garnet ne se rattache pas aux facteurs des barbes. La ségrégation des barbes dans les F2 et F3 a donné la relation dihybride que voici: 5 sans barbes: 5 à barbe apicale: 5 à barbes raccourcies: 1 barbu. Les parents portaient différents facteurs tendant à la suppression des barbes et ces facteurs se sont comportés de façon cumulative en restreignant l'expression des barbes. La transmission héréditaire de la précocité et des barbes paraissait être indépendante, car on a obtenu, dans chaque catégorie de barbes, des lignées hâtives, intermédiaires et tardives de F3.

A STUDY OF SOME INGREDIENTS FOUND IN ENSILAGE JUICE AND ITS EFFECT ON THE VITALITY OF CERTAIN WEED SEEDS

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INTRODUCTION

During periods of drought such as we have just experienced, an acute shortage of fodder often causes material to be fed which would otherwise be discarded. Consequently there is a danger that this will add to our already serious weed problem.

Because the vitality of seeds is not destroyed by passing through the intestinal tract of farm animals (Harmon and Keim, (9)), the effect of ensiling them was tested.

Chemical determinations were made on the ensilage juice, and some of the ingredients were tested for their effect on the vitality of seeds.

REVIEW OF LITERATURE

No information could be found on the effect of including seeds in silos, but Piemeisel (13) found that the viability of spores of corn smut (*Ustilago Zeae*) was destroyed after several weeks in silo. He also found that a 1% solution of lactic or acetic acid, or a combination of both, would destroy vitality.

In the United States, Esten and Mason (8), among others, found the acid content of silage juice to be 1% to 2%. Dox and Neidig (6, 7), Neidig (11), and Lamb (10), found this range approximately correct. They also found the principal acids to be lactic and acetic, the non-volatile lactic acid being in the largest proportions in normal corn silage. Acid formation was complete in seven or eight days.

In England, Amos and Woodman (2, 3, 4), and Woodman and Hanley (15), examined the juice from several crops stored under three different methods of ensiling. They found that the proportion of volatile to non-volatile acid depended on conditions within the silo, but good ensilage produced a predominance of non-volatile acid.

Amos and Williams (1), in studying the effect of temperature on quality of ensilage, found a maximum of 63.5° C. at the top, and 37° C. at the centre of a tower silo. This is typical of temperatures recorded, both in England and the United States.

Changes take place quite rapidly within the silo. Neidig (11) found that all the oxygen had disappeared within three days. He also found, as did Lamb (10), that CO_2 developed rapidly during the first few days.

Both Neidig and Amos and Woodman (2) showed that the organic acid was completely destroyed in the top layer of silage, where the presence of air induced higher temperature and the growth of moulds.

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EXPERIMENTAL

Experiment 1. Examination of Silage Juice and Its Effect on the Germination of Weed Seeds

In 1931 corn from test plots was cut and put into galvanized cans 30 inches in diameter and 30 inches high. When half full a damp cotton cloth was spread over the surface and 500 seeds of 19 species of weeds were distributed on this. After covering with another layer of cotton the filling was completed. The silos were then covered with wooden tops which just fitted inside the cans. These were weighted with 70 lb.-bags of sand. The experimental silos were stored in an unheated building.

The temperature of each silo was taken daily by pushing a thermometer 11″ into the silage through a hole half-way down the side of the can. Pressure from the sand-bags prevented air-holes forming at these points.

The temperature rose in the first two days to a mean of 23° C. and remained between 23° C. and 24.5° C. for two weeks when it dropped to 20° C. Daily recordings were continued for another 24 days during which time the mean temperature varied a degree or so on either side of this point. The widest variation between silo temperatures on any day was 5.5° C. This was on October 14th on which day the highest temperature, 28° C. was recorded.

Silos were opened every fifteen days and the seeds sent to the Dominion Seed Branch District Laboratory, Winnipeg, Manitoba, where all germination tests reported in the first part of this paper were made.

When the second silo was opened, a sample of ensilage was removed for chemical analysis from both sides of the cotton layer. The juice was removed from this by pressure, giving a very dark solution. The method for volatile and non-volatile organic acids used by Lamb (10) proved inadequate, and a modification of Forman's titration method as outlined by Woodman (14) was tried on the last sample. This method proved satisfactory, and was used for all analyses reported in this paper. Alcohol was determined by the aeration method of Dox and Lamb (5).

In 1932 experimental silos were filled with corn that was being filled into the large silos on the college farm. This crop contained an average of 7500 *C. album* and *A. retroflexus* seeds per pound.

Temperatures were taken as before with much the same results except that the mean was slightly lower, the maximum was 23° C. and the widest range between silos 2° C.

TABLE 1.—PERCENTAGE GERMINATION OF SEEDS FROM EXPERIMENTAL SILOS

Seed species	Days in silo							
	1931				1932			
	14	21	26	Ck.	9	15	21	Ck.
Chenopodium album L.	34	2	0	82	40	20	0	76
Amaranthus restoflexus, L.	0	0	0	45	4	0	0	85
A. graecizans, L.	—	—	—	—	58	0	0	21
Silene noctiflora, L.	0	2	0	45	0	0	0	68

TABLE 2.—ANALYSES OF SILAGE EXTRACT EXPERIMENTAL SILOS, 1932

Lab. No.	Date	Moisture	Alcohol		Vol. acid		Non-vol.		Total acid		Ameno acid	Vol. base
			% of moisture	% of total	% of moisture	% of total	% of moisture	% of total	% of moisture	% of total	As Cr. protein	As Cr. protein
1	Sept. 8	77.98			0.44	0.34	1.31	1.02	2.11	1.56	0.44	0.12
2	Sept. 15	78.00			.52	.41	1.70	1.32	2.69	2.10	.39	.12
3	Sept. 21	79.15	0.06	0.05	.55	.43	1.57	1.24	2.74	2.17	.37	.10
4	Sept. 27	78.46	.08	.07	.48	.38	1.73	1.36	3.07	2.42	.51	.15
5	Oct. 6	78.67			.59	.47	1.74	1.37	2.93	2.34	.31	.14
6	Oct. 13	69.36	.27	.24	.49	.39	1.68	1.28	2.99	2.07	.53	.12
7	Oct. 21	79.56	.33	.26	.43	.34	1.56	1.24	2.77	2.19	.48	.14
8	Oct. 29	79.06	.28	.23	.53	.42	1.55	1.22	2.78	2.13	.43	.13
9	Nov. 4	79.14	.24	.19	.50	.39	1.64	1.30	2.77	2.19	.53	.11
Average		77.71	.21	.20	.50	.40	1.61	1.26	2.76	2.13	.44	.12
Dairy silo	Oct. 21	72.44	.39	.28	.45	.32	1.44	1.04	2.67	1.93	.43	.16

The first silo was opened ten days after filling, and another every seven days thereafter and seeds of all species sent for germination.

All species which showed any germination in either year are included in Table 1. The 20 species which did not germinate are included in Table 5 together with their normal germination in both years. Most of the seeds used were hand harvested from the weed garden in 1931. The germination of check samples in both these tables indicate that several of these species have a definite after-ripening period.

No species showed any germination after 21 days in the silo.

Instead of pressing the juice from the samples for chemical analysis, as was done in 1931, they were run through a meat grinder. After thorough mixing, duplicate samples of 1000 gms. were weighed into wide-mouthed bottles and shaken for two hours with water. The liquid was filtered off, the residue washed free of acid, and the filtrates combined and measured. This treatment gave a bright clear solution with the modified Forman method, and checked reasonably closely with the one sample analysed by this method in 1931.

Because the seeds were exposed to the action of the juice (water and solubles) only, the results have been reported as percentage of moisture. Moisture was calculated on oven dry basis, and therefore included most of the volatile acids, bases and alcohol.

Besides the sample for chemical analysis, samples were taken from the top, centre and bottom of each silo. The weed seeds were washed out of these and weighed, and 100 seeds from each part were sent for germination test, the results of which are reported in Table 3.

The data in Table 3 show that the seeds taken from the top layer of silage retain a certain amount of their vitality. The germination is somewhat erratic, but the material from which these seeds were washed contained varying amounts of good silage. Generally speaking, the seeds from the top of the silos germinated quite well.

TABLE 3.—GERMINATION OF SEEDS FROM DIFFERENT PARTS OF SILOS

Days in silo	21 Days in germinator		
	Top	Center	Bottom
9	8	0	0
15	30	0	0
21	16	0	0
29	36	0	0
38	6	0	0
44	25	0	0
52	14	0	0
60	35	0	0
65	13	0	0

It is known that the organic acids are destroyed at the surface of a silo, also that the concentration of CO_2 will be much less in this area. The writer therefore decided to test the action of these two constituents to see if they were responsible, combined or singly, for the loss of germinating power.

It was not until 1935 that an opportunity presented itself, and a supply of terminal elevator screenings was obtained. These were supplemented by some hand-picked samples of five species from the collection of Mr. George A. Elliott, Supervising Analyst at the Ottawa District Laboratory of the Dominion Seed Branch, to whom I am also indebted for the germination tests reported below.

TABLE 4. GERMINATION OF SEEDS KEPT MOISTENED WITH WATER OR ORGANIC ACIDS: IN AIR AND CARBON DIOXIDE

Seed species	Closed vessels					CO_2		Washed air					Check
	Water				Mixed acid	H_2O	Mixed acid	Water			Mixed acid	2.5 acid	Not soaked
	2 wk.	3 wk.	4 wk.	5 wk.				2 wk.	3 wk.	4 wk.			
Agropyron repens (L.) Beauv.	–	–	–	–	–			52	?	?			99
Avena fatua L.	–	–	–	–	–			27	30	30			74
Rumex crispus L.	–	–	–	–	–			75	96	47			98
Polygonum Convolvulus L.	60	46	28	34	0			72	53	65			64
P. Colvolvulus (hulled)	3	2	6	0	0			–	–	–			51
Chenopodium album L.	14	14	7	15	0			36	24	–			70
C. album (Elliott)	–	–	–	–	–	No		20	17	27	No		76
Amaranthus retroflexus L.	8	8	10	10	0	germination		20	24	22	germination		74
A. retroflexus (hulled)	0	0	0	0	0			–	–	–			15
A. retroflexus (Elliott)	–	–	–	–	–			90	89	40			83
Silene noctiflora L.	–	–	–	–	–			53	74	99			100
Thlaspi arvense L.	46	27	0	0	0			64	14	18			77
Brassica spp.	2	0	0	0	0			10	3	9			27
Neslia paniculata (L.) Desu.	10	0	0	0	0			–	–	–			46

The acid and CO_2 treatments, showing no germination, had tests made each week but it was not considered necessary to include these extra headings in Table 4.

Experiment 2. Effect of Some Organic Acids on the Viability of Certain Weed Seeds in Air and in CO_2

Four pint sealers were fitted with rubber stoppers equipped with separatory funnels; two were also fitted with two glass tubes each. Eight species were counted into lots of 100, folded in filter paper, and then four of each were wrapped in cheese-cloth and placed on a layer of glass beads in each sealer. Two of the funnels were filled with water, and two with a mixture of lactic and acetic acid (14.76 cc. C.P. lactic plus 8.57 cc. 95% glacial acetic per litre) to equal the average acid content of the silage as shown in Table 1.

One sealer with acid and one with water were closed tight. The remaining two were attached to a CO_2 generator on one side and an air trap on the other. Enough liquid was turned into each bottle to wet the seeds, but no packets were ever allowed to stand in liquid.

One complete set of seeds was sent for germination test on the 14th, 21st, 28th and 35th days after closing the bottles.

When this experiment was under way it was realized that soaking seeds in water within a closed vessel would lead to the accumulation of the products of respiration. Pei-sung Tang (12) increased the germination of wheat by aeration of the nutrient solution to remove the products of respiration. With this in mind three more sealers were connected into a train through which as tream of air was drawn. A CO_2 trap was placed after each sealer. The solutions used on the seeds were the same as before with the addition of one sealer, using 2.5% acetic acid.

Experiment 3. Bulk Treatment of Seeds with Acetic Acid

Two lots of 200 gms. of screenings were weighed into sealers dampened with 3% and 10% acetic acid, and allowed to stand for 12 days. (50 to 60 cc. of solution were used for each sealer.)

On the twelfth day samples were taken from the top, centre and bottom of the sealers, and sets of 100 seeds of all species present in large enough quantities were sent for germination. None of these seeds showed vitality during six weeks in the germinators. (Germination of untreated checks is given in Table 6.)

Experiment 4. Effect of Time of Exposure and Concentration of Acid on Chenopodium album L. seeds

Chenopodium album seeds were counted into lots of 100, folded into filter paper, done up in bundles of seven, and put into the four bottles as in Experiment 1. The separatory funnels contained 2%, 1%, 0.5%, 0.25% solutions of acetic acid. Only *C. album* seed was used as this species had proven most resistant. One packet was taken out of each bottle every day for seven days and tested for germination.

As germinator space was restricted it was difficult to prevent an occasional seed from being shaken from one blotter to another during manipulation. It is possible that seeds shown in the table as germinating on 7th and 8th days from 1% and 2% solutions were shaken from adjacent check samples.

TABLE 5.—GERMINATION OF *Chenopodium album* SEEDS EXPOSED TO VARIOUS CONCENTRATIONS OF ACETIC ACID FOR ONE TO EIGHT DAYS

Acid, %	Number of days in acid							Total	Check
	1	2	4	5	6	7	8		
2.00	2	1	0	0	0	0	1	4	76
1.00	11	2	0	0	0	1	0	14	71
0.50	19	12	2	1	2	0	0	36	70
0.25	64	38	4	3	2	0	0	111	75
Total	96	53	6	4	4	1	1	165	

Variance due to time exposed F. = 0.5200. 5% point 0.4894.
Variance due to concentration F. = 0.5086. 5% point 0.5753.
Correlation between Germination and Time exposed to 0.25% acid = −0.82. t = 3.194. 5% point 2.571.
Correlation between Germination and Concentration = −0.72. t. = 1.414: not significant.

CONCLUSIONS

The results from two season's work with silos show that something occurs within them to reduce, and eventually inhibit, the germination of a number of our common weed seeds. It is also evident that this effect is not as noticeable at the surface of the silos as deeper down. As a certain amount of heat is generated at the surface, high temperatures cannot be the cause.

Analysis of silage juice shows an appreciable amount of organic acids present in the centre of the silos. Woodman *et al* have shown that the other constituents of silage juice are not greatly changed at the surface, although the acids are destroyed. The other condition which might be expected to differ is the presence of CO_2 in the lower parts of the silo. The presence of air, which causes the few surface inches of silage to differ from the rest, would be expected to at least dilute the CO_2 formed there.

When column one in Table 4 is compared with column five, there is an indication that the products of respiration have a depressing effect on germination. The only test with the seeds in an atmosphere of pure CO_2 is shown in column three. In this case where conditions were practically the same as in columns one and five, there was no germination from any species tested. These tests are too small to constitute proofs but they do indicate definite effects under single conditions of moisture and temperature.

Regarding the effect of organic acids, the evidence is more conclusive. In none of the tests have any of the seeds survived more than 21 days, when dampened with either acetic acid alone or a mixture of acetic and lactic acids.

The most surprising result to the writer was the complete lack of germination shown by the bulk sample of screenings in Experiment 3. This material was moistened with a 3% solution of acetic acid. Just enough solution was used to moisten all the seeds without allowing any surplus to collect in the bottom of the sealers. A loose cover placed on top did not prevent the surface seeds drying after the first day. Further investigation along this line might develop an economical method for treating screenings for feeding purposes.

TABLE 6.—GERMINATION OF SEEDS WHICH SHOWED COMPLETE LOSS OF VITALITY WHEN TREATED WITH ENSILAGE JUICE OR ACETIC ACID

Genus—species	Common name	Germination of check tests in %		
		1931	1932	1936
Agropyron repens (L.) Beauv.	Couch Grass			99
Avena fatua L.	Wild Oats	12	85	99
Echinochloa crusgalli (L.) Beauv.	Barnyard Grass	16	61	
Setaria glauca (L.) Beauv.	Yellow Foxtail	20	6	
Polygonum Convolvulus L.	Wild Buckwheat	8		64
Chenopodium album L.	Lamb's Quarters	82	76	72
Amaranthus retroflexus L.	Red-root Pigweed	12	85	84
A. gracizans	Tumbleweed		21	
Saponaris Vaccaria L.	Cow Cockel	1	2	
Saline noctiflora L.	Night-flowering Catchfly	45	68	100
Thlaspi arvense L.	Stink Weed	54	65	77
Capsella Bursa-pastoris (L.) Medic	Shepherd's Purse	92	60	
Camelina sativa Chntz.	False Flax	88	66	
Corringia orientalis (L.) Desu	Hare's Ear Mustard	50	69	
Brassica arvensis B.S.P.	Common Mustard	93		27
B. Juncea L.	Indian Mustard	97	99	46
Neslia paniculata (L.) Deus.	Ball Mustard	73	52	
Portulaca oleracea L.	Purselane	38	46	
Lappula echinata Gilbert.	Blue Burr		94	
Plantigo major L.	Plantain	96	94	
Euphorbia glyptosperma Englm.	Gidge-seeded Spurge	7		
Sonchus arvenses L.	Sow-thistle		43	
Other Seeds Tested in Small Numbers Without Checks				
Avena sativa L.	Oats			
Triticum vulgari L.	Wheat			
Setaria viridis (L.) Beauv.	Green Foxtail			
Salsola Kali L.	Russian Thistle			
Axyris amaranthoides L.	Russian Pigweed			
Sisymbrium altissimum L.	Tumbling Mustard			
Alsine Media L.	Chickweed			
Circium arvense (L.) Scop.	Canada Thistle			

The last experiment was a preliminary test of the effect of time of exposure and concentration on germination. Taking the previous results into consideration, it seems reasonable to confine tests to *Chenopodium album* and eliminate the tedious work of counting out test lots of numerous species and conserve germinator space. By Fisher's Table of "K" the varianc due to time exposed to the solution was significant, but variance due to concentration was just above the 5% point. The correlation between germination and time exposed to the 0.25% solution was also significant. More extensive tests need to be carried out to arrive at definite conclusions regarding the tolerance of this species to acetic acid, also to what extent changes in temperature would affect this tolerance.

Considering the above data as a whole, it can be concluded that the principal cause for reduced viability of seeds enclosed within silos is the organic acid content of the silage juice. Low concentrations of these acids, and of acetic acid alone, will effectively destroy the viability of the twenty-odd species tested within twenty-one days at room temperatures. More information is required before any definite statement can be given

regarding the exact time necessary or the concentration below 2% required to accomplish this. It is also indicated that an atmosphere of pure CO_2 will destroy the viability of certain seeds when moistened with water and held at room temperature for 14 days or more. Further tests would be necessary to verify this.

SUMMARY

The seeds of 19 species of weeds were included in experimental silos during two periods.

The vitality of all species except *Chenopodium album* was destroyed after 14 days in the 1931 tests, and 9 days in 1932. *Chenopodium* survived up to 21 days. Seeds in the top of the silos showed considerable germination.

Chemical examination showed 1.5% to 2.0% of organic acids present in silage juice.

Seeds treated with approximate concentration of acetic and lactic acids showed complete destruction of vitality in 14 days whether kept in air or CO_2.

Seeds treated with water in CO_2 showed complete loss of vitality.

Concentrations of 2% acetic acid destroyed vitality of *Chenopodium album* in 48 hours and 0.25% in six days.

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Résumé

Étude de certains ingrédients trouvés dans le jus de l'ensilage et leur effet sur la vitalité de certaines mauvaises herbes. W. T. Tildesley, Division fédérale des semences, Ottawa, Ont.

Les graines de 19 espèces de mauvaises herbes ont été mises et laissées dans des silos d'essai pendant deux périodes de temps. Au bout de 14 jours, dans les essais de 1931, et au bout de 9 jours dans ceux de 1932, toutes les espèces de graines avaient péri à l'exception de *Chenopodium album.* Celle-ci a survécu 21 jours. Les graines sur le dessus des silos avaient encore une puissante faculté de germination. L'examen chimique a révélé la présence de 1.5% à 2.0% d'acides organiques dans les jus de l'ensilage. Les graines traitées avec une concentration approximative d'acide acétique et d'acide lactique avaient complètement perdu leur vitalité au bout de 14 jours, qu'elles soient gardées à l'air ou dans l'acide carbonique. Les graines traitées avec de l'eau dans l'acide carbonique ont perdu toute leur vitalité. Des concentrations à 2% d'acide acétique ont détruit la vitalité de *Chenopodium album* en 48 heures, et les concentrations à 0.25% l'ont détruite en 6 jours.

THE EFFECT OF DATE OF SOWING UPON THE COMPARATIVE PERFORMANCE OF TWO WHEAT VARIETIES[1]

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INTRODUCTION AND LITERATURE REVIEW

The subject of local adaptation of varieties has, during comparatively recent years, been receiving a large amount of attention. It s now generally recognized that varieties have definite preferences for areas with a certain combination of soil and climatic conditions. Grown under these conditions they give a highly satisfactory performance but often when an attempt is made to cultivate them under another set of conditions the results are disappointing. However the moving of a variety from one locality to another is not the only way in which it may be subjected to different environments. For instance, increasing or decreasing the rate of sowing is a very effective way of altering the conditions under which a variety produces its yield and Engledow (2) has shown that varieties may respond differentially to variations in spacing. The relation of a variety to a certain environment may also be effectively altered by sowing it at different times. It is obvious that wheat sown on the 20th of April germinates and passes through critical stages of growth under different temperature, moisture, and light conditions than if seeding were delayed until the 20th of May.

That time of planting affected several winter wheat varieties differentially, under conditions of winter killing and Hessian fly prevalence, has been shown by Suneson and Kiesselbach (13). Bayles and Martin (1) also found a differential response on the part of winter wheat varieties to time of sowing and they showed that the spring wheats, Marquis and Federation, responded differently when sown at two widely separated dates in the spring. Martin (11) in discussing the results of a number of rates and dates of seeding experiments conducted at different stations in the United States came to the conclusion that the effect of variety upon date of seeding was slight. However he noted that some varieties appeared to be affected to a lesser degree by late sowing than others and that this was a feature worthy of further investigation. An experiment conducted by the Dominion Experimental Station at Scott in 1925 gave interesting results (4). Marquis and Garnet were sown at five different dates on both spring plowing and summerfallow. In both cases the varieties responded differentially to time of sowing but the direction of the response on spring plowing was directly opposite to that on summerfallow. Hale (9) in 1936 showed very marked differential responses, on the part of cotton varieties, to being sown at different times. Florell (6) in 1929 found distinct differences in the comparative performances of varieties of both wheat and barley to different times of planting

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Although many dates of seeding experiments have been conducted in Western Canada and have yielded much valuable information, they have, for the most part, been concerned with crops and not with varieties of cr ps. Thus there is a decided scarcity of information with respect to the effect of time of sowing upon varieties. When it is considered that each of the leading varieties of wheat in the Prairie Provinces occupies thousands of acres of land, and that they are commonly sown anywhere between the last week in April and the end of May, it is evident that a difference in the response of these varieties to time of sowing could be of very considerable importance.

In 1931 an experiment in which four varieties of wheat were sown at nine weekly intervals in the spring was commenced at the University of Saskatchewan at Saskatoon, Sask., and has been continued with some alterations during the past five years. A preliminary report of this experiment has been published previously by Harrington and Horner (10). In this paper it was shown that the varieties, Marquis, Reward, Garnet and Ceres, were not only very sensitive to small changes in environment but also that they often responded to such changes in different ways. This was true of both characters studied—yield and height. While the study of these two characters shows the gross effects of certain environmental changes upon a variety it fails to indicate the manner in which a variety may adjust itself to those changes in environment and produce its yield. It also fails to give information regarding the growth characteristics of the variety, its peculiar abilities or weaknesses and how it was able to produce well under a certain environment or was less successful under another. The experimenter can say only what its final production had been under certain conditions and compare this result with those of other varieties.

It is obvious that the productive ability of a variety is dependent upon the actions and interactions of a great complexity of plant factors. Engledow and Ramiah (3) who have done much to clarify the problem of yield analysis set forth the problem as being, ultimately, the identification of all the characters which influence plant growth and life combined with a knowledge of their relation to yield and various external factors. However they say the immediate problem must be limited to a study of simple morphological and physiological characters under varying environments. Since at present these have no absolute meaning or measurement their only significance can be in the form of inter-varietal comparison under different environments.

A dates of seeding experiment offers almost ideal material for such a comparison. In it a group of varieties are subjected to a precise series of from small to large environmental changes and yet are grown in a compact test located at one station. The amount of labour which could be devoted to this experiment was limited; nevertheless it was felt that the study of some of the more important factors involved in the production of yield would make possible a more fundamental comparison of the reaction of the varieties to dates of sowing than if yield alone was used. Three characters were selected for study: number of spikes per plot, number of kernels per spike and weight per kernel. Data on these characters may be obtained with comparatively little difficulty. Together they determine

yield and each is finally constituted during a different stage in the growth of the plant. Studied in conjunction with yield, they should show quite clearly the manner of response of each variety to being sown at different times.

MATERIALS AND METHODS

Since the detailed procedure in this study varied somewhat from year to year it will be described more completely in the discussion of the results of the individual years and only a general outline given here.

The experiment was planned in 1930 by Dr. J. B. Harrington[3] and conducted in a preliminary manner in 1931, using four varieties replicated six times at each of nine sowing dates, which were one week apart. In 1932 five varieties were sown in the form of a Latin Square at each of nine weekly dates. Financial stringency necessitated the reduction of the project and it was continued in 1933 and 1934 sowing two varieties in six replicates at each of nine weekly dates.

During these four years the arrangement of the sowing dates was systematic, having been sown one beside the other in the order of time of sowing. The varieties were randomized in each replicate. That this arrangement of the dates of sowing, could, on soil showing an appreciable gradation in fertility, seriously interfere with the results was recognized. Since the dates of seeding experiment had in every year been conducted on the regular cereal nursery plots the yields obtained in previous years from the same soil, on which the dates of seeding experiment was located, were available. Each date required an area 6 feet wide and 132 feet long and the soil fertility map drawn on the basis of the rod row plot yields of grain showed only very slight changes in fertility crosswise of the dates. The one exception was in 1933 when the soil on which the last five dates were sown showed a steady increase in fertility from the fourth date to the ninth. The increase over the five dates was slightly over ten per cent. No relationship was found between the yields of dates and the soil fertility maps in any year. It therefore was concluded that the systematic arrangement of the dates had not affected the results appreciably. In 1935 the experiment was continued with two varieties replicated five times at each of nine weekly dates, which in this year were randomized within the replicates, the varieties being randomized within dates. The varieties used in the test were: Marquis (Sask. 100), Reward (Sask. 1003), Garnet (Sask. 791), Ceres (Sask. 1212), and Reliance (Sask. 1851)[4]. Because data on the three components of yield were obtained on Ceres, Reliance, and Garnet in 1932 only, these data are being omitted from the paper. However, Marquis and Reward were studied in detail in each of the four years: 1932, 1933, 1934 and 1935. These years constituted a very representative assortment including one extremely dry season, one fairly wet one and two moderately dry ones.

Data were analysed by using Fisher's Variance Analysis (5). This form of analysis is particularly suited to such an experiment, because, by permitting the apportionment of the variation into its several components the experimenter may study not only the individual factors but also the very important interactions between them. Since in this experiment

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[4] The Canadian Accession numbers for these stocks are: 169₁, 1509, 1316, 1263, and 1498, respectively.

varieties were randomized within dates of sowing it is necessary to have two errors—the one to be applied to the large plots which were sown at different dates, and the other to be applied to the individual rod row plots in which the varieties were sown (7). An example of the analysis may be seen in Table 1 which shows the analysis of variance of yields in 1935. The significance of the various criteria and their interactions was obtained by dividing their variance by the appropriate error variance in order to get an F value. This is compared to the calculated F values for the 5% and 1% points obtained from Table XXXV values of F by Snedecor (12).

TABLE 1.—ANALYSIS OF VARIANCE OF THE YIELD OBTAINED IN THE DATES OF SEEDING EXPERIMENT IN 1935

Source of variation	D.F.	Sum of squares	Variance	F Value	5% Point	1% Point
Between means of dates	8	592,548	74,069	26.01	2.27	3.17
Between means of replicates	4	11,618	2,905	1.10	2.69	4.02
Interaction dates—replicates	32	91,107	2,847.1		(Error 1)	
Between means of varieties	1	495	495			
Interaction dates—varieties	8	23,945	2,993	5.98	2.22	3.07
Remainder	36	18,015	500.4		(Error 2)	
Total	89	737,728				

$SE.\ \sqrt{500.4} = 22.4$

SE_M of 5 plots $= \dfrac{22.4 \times 100}{\sqrt{5} \times 270} = 3.7\%$

NOTE.—SE_M means standard error of mean yield.

EXPERIMENTAL RESULTS

1931 Results

The results for height and yield of the test in 1931 have been published previously (10). Since no data on the three components of yield were obtained in that year there is nothing to add to the previous paper.

1932 Results

In 1932 data were obtained on number of spikes per foot, number of seeds per spike and the weight of the seed. The number of spikes per plot was obtained by making a stubble count on six one-foot sections of the centre row. Sixteen spike samples were obtained from each plot in the first three replicates and number of seeds per spike was determined from them. Weight of the seed is expressed in the conventional manner, "Weight per thousand kernels", and was obtained by weighing six one-hundred kernel samples drawn from the bulked yields of the five replicates. Principles of random sampling were observed throughout.

In Table 2 the results obtained in 1932 for yield and for the three components of yield are presented. Values entered in the column headed "M-R" were obtained by subtracting the value of Reward, for a particular character at a certain date of sowing, from the corresponding value of Marquis. In this column any differential response of the varieties to time of sowing may be seen with a glance. The F value for the interaction of varieties with dates of sowing for each character is shown in the lower

TABLE 2.—SUMMARY OF YIELD AND YIELD CHARACTERS IN 1932. THE AVERAGE RESULTS FOR MARQUIS AND REWARD SOWN IN FIVE REPLICATE TRIPLE ROD ROW PLOTS AT NINE WEEKLY INTERVALS IN 1932

Date of sowing		Yield in grams per row			No. of spikes per foot			No. of seeds per spike			Weight per thousand kernels		
Month	Day	Marquis	Reward	M-R	Marquis	Reward	M-R	Marquis	Reward	M-R	Marquis	Reward	M-R
April	15	357	303	54	40	38	2	26	22	4	28	31	−3
April	26	349	301	48	35	37	−2	27	21	6	30	32	−2
May	2	346	295	51	36	36	0	27	21	6	29	32	−3
May	7	304	254	50	34	38	−4	27	18	9	29	31	−2
May	14	274	239	35	32	37	−5	25	18	7	26	30	−4
May	21	252	238	14	35	34	1	22	17	5	26	27	−1
May	28	186	208	−22	33	40	−7	20	16	4	23	26	−3
June	4	171	189	−18	31	33	−2	19	18	1	22	23	−1
June	11	181	205	−24	29	33	−4	22	19	3	25	25	0
Varieties × Dates													
F value			7.02			3.50			2.23				
5% point			2.22			1.96			2.51				
1% point			3.07			2.55			3.71				
SE_M of 5 plots			3.5%			7.5%			4.5%*				

* SE_M of three plots.

portion of the table with the corresponding 5% and 1% points taken from Snedecor's Table XXXV for comparison.

The interaction of varieties with dates was highly significant, for yield and number of spikes per foot. Marquis yielded considerably more than Reward in the first five sowings, but in the last three, Reward outyielded Marquis. In number of spikes per foot Reward increased the slight advantage it enjoyed over Marquis in the early sowings to a significant superiority in the later ones. Marquis was distinctly superior to Reward in number of seeds per spike but in this case the interaction was not significant. There was an indication of a differential response in weight of seed; the size of seed in Reward seemed to be reduced more by late sowing than in Marquis.

Generally, Marquis was superior to Reward when the two varieties were sown early. This superiority was due to the larger spikes of Marquis which was sufficient to more than offset the somewhat larger seeds and greater numer of spikes in Reward. When the varieties were sown late their relative yielding abilities as compared with early sowings were reversed. This was because Reward suffered less from late sowing, both in number of spikes per foot and number of seeds per spike than did Marquis, although the latter did not lose as much in weight of seed.

1933 Results

The season of 1933 was very dry, and the varieties yielded less than half the amount of the previous year.

The same method of sampling was used in obtaining stubble counts as in 1932. Thousand kernel weight was determined by weighing one

two-hundred kernel sample from the yield of each plot. Since a rates of sowing experiment which was being conducted at the time indicated that Reward preferred heavier seeding than Marquis the practice of sowing Reward at one hundred and ten pounds per acre instead of the usual ninety was adopted in 1933 and continued in 1934 and 1935. Although this difference in rate of sowing would probably have some effect upon number of spikes per foot and possibly on number of seeds per spike, it seems unlikely that the interaction of varieties with dates for either of these characters would be affected.

TABLE 3.—SUMMARY OF YIELD AND YIELD CHARACTERS IN 1933. THE AVERAGE RESULTS FOR MARQUIS AND REWARD SOWN IN SIX REPLICATE TRIPLE ROD ROW PLOTS AT NINE WEEKLY INTERVALS IN 1933

Date of sowing		Yield in grams per row			No. of spikes per foot			No. of seeds* per spike			Weight per thousand kernels		
Month	Day	Marquis	Reward	M-R	Marquis	Reward	M-R	Marquis	Reward	M-R	Marquis	Reward	M-R
April	19	125	94	31	27	29	−2				24	27	−3
April	28	163	141	22	30	41	−11				25	26	−1
May	5	159	157	2	27	38	−11				26	24	2
May	12	146	140	6	25	28	−3				26	27	−1
May	19	144	148	−4	29	38	−9				26	26	0
May	26	131	118	13	30	37	−7				25	25	0
June	2	146	151	−5	27	36	−9				26	26	0
June	9	122	128	−6	28	39	−11				26	24	2
June	16	123	101	22	28	32	−4				24	24	0
Var. × Dates													
F value			2.61			6.58						9.41	
5% point			2.15			1.96						2.15	
1% point			2.94			2.55						2.94	
SE_M of 6 plots			4.4%			7.9%						1.46%	

* No spike samples were taken in 1933.

An examination of the results for yield in Table 3 shows that date of sowing affected yield to a far less extent in 1933 than in 1932. It is also evident that the effect of date of sowing in 1933 of causing sharp upward or downward fluctuations in yield, between one date and the next, was markedly different to the fairly consistent tendency of high yields in the early sowings and low yields in the late sowings exhibited in 1932. The interaction of dates of sowing with varieties was significant, Reward yielding much lower than Marquis in the extremely early and late sowings and almost equal to it in the intermediate sowings. In number of spikes per foot Reward was definitely superior to Marquis except in the sowings of April 19, May 12 and June 16, in which Reward had an unusually low number of spikes. The interaction of varieties with dates for thousand kernel weight was highly significant. Since Reward had a considerably greater number of spikes per foot and there was little difference between the varieties in weight per thousand kernels, wherever Marquis excelled

Reward in yield it must have done so by having a greater number of seeds per spike than Reward.

In 1933 conditions were such that the environment under which a crop was produced experienced extreme changes within so short a period that there were marked differences in yield between sowings made only one week apart. To these changes Marquis and Reward reacted in different ways. Not infrequently the conditions which produced a marked reduction in the yield of one variety had very little effect upon the yield of the other. Reward appeared to be more sensitive to environmental changes than Marquis, as evidenced by its greater fluctuations in yield. These fluctuations were caused most often by variations in stooling or number of spikes per foot, though it is evident that in some cases the number of seeds per spike must have been partially responsible.

1934 Results

In 1934, although the spring was very dry, a good supply of moisture from the previous fall, together with a June rainfall of about four inches, enabled grain which was sown fairly early to produce high yields.

TABLE 4. SUMMARY OF YIELD AND YIELD CHARACTERS IN 1934. THE AVERAGE RESULTS FOR MARQUIS AND REWARD SOWN IN SIX REPLICATE TRIPLE ROD ROW PLOTS AT NINE WEEKLY INTERVALS IN 1934

Date of sowing		Yield in grams per row			No. of spikes per foot			No. of seeds per spike			Weight per thousand kernels		
Month	Day	Marquis	Reward	M-R	Marquis	Reward	M-R	Marquis	Reward	M-R	Marquis	Reward	M-R
April	20	240	202	38	37	32	5	25	19	6	25	26	−1
April	27	234	227	7	36	45	−9	25	17	8	24	27	−3
May	4	243	240	3	35	49	−14	24	15	9	25	27	−2
May	11	246	235	11	35	47	−12	25	17	8	26	25	1
May	18	207	208	−1	37	36	1	24	20	4	25	25	0
May	25	194	204	−10	32	33	−1	24	21	3	26	27	−1
June	1	193	187	6	29	29	0	25	21	4	27	28	−1
June	8	197	204	−7	29	28	1	25	22	3	25	29	−4
June	15	161	173	−12	26	27	−1	20	21	−1	27	28	−1
Var. × Dates													
F value		1.74			1.03			28.7			4.8		
5% point		2.15			2.00			1.97			2.15		
1% point		2.94			2.63			2.57			2.94		
SE_M of 6 plots		3.85%			6.78%			7.05%			1.82%		

Number of spikes per foot was obtained by counting two samples of stubble of two feet each. Four spike samples were taken from each plot in the six replicates. The weight per thousand kernels was obtained by using the same method as in 1933.

Although Marquis appeared to excel Reward in the early sowings while Reward excelled Marquis in the later sowings (Table 4), the analysis of variance showed this interaction to be non-significant. Similarly in number of spikes per foot the interaction of varieties with time of sowing

was not significant, although in the early sowings Reward appeared to have distinctly more spikes than did Marquis while there was practically no difference between the varieties in the later sowings. In number of seeds per spike Marquis was again definitely superior to Reward. However the advantage which Marquis enjoyed over Reward for this character was only half as much in the late as it was in the early sowings. Analysis proved this interaction to be significant. In weight per thousand kernels Reward was superior to Marquis, but in this character the relative merits of the two varieties was subject to considerable variation which accounts for the significant interaction of dates with varieties.

Marquis, as in previous years, was superior to Reward in yield, realizing this advantage through having more seeds per spike. This advantage more than overbalanced the superiority of Reward in number of spikes and weight of seed. Reward seemed to effect fluctuations in yield largely through a reduction or enhancement of the number of spikes, while in Marquis the change was usually produced by comparatively small increases or decreases in all three yield components.

1935 Results

In 1935 good rains during early June and some during early July resulted in the production of fairly good yields in the early sowings. Late sown grain however seemed unable to utilize the moisture as efficiently, and some very low yields were produced.

TABLE 5.—SUMMARY OF YIELD AND YIELD CHARACTERS IN 1935. THE AVERAGE RESULTS FOR MARQUIS AND REWARD SOWN IN FIVE REPLICATE TRIPLE ROD ROW PLOTS AT NINE WEEKLY INTERVALS IN 1935

Date of sowing		Yield in grams per row			No. of spikes per foot			No. of seeds per spike			Weight per thousand kernels		
Month	Day	Marquis	Reward	M-R	Marquis	Reward	M-R	Marquis	Reward	M-R	Marquis	Reward	M-R
April	23	326	342	−16	44	54	−10	25	19	6	28	30	−2
April	29	371	371	0	51	56	−5	26	20	6	27	29	−2
May	7	333	312	21	48	49	−1	25	20	5	26	28	−2
May	13	297	250	47	40	41	−1	25	21	4	25	28	−3
May	20	349	323	26	44	43	1	26	22	4	27	29	−2
May	28	265	269	−4	38	42	−4	23	19	4	29	30	−1
June	3	236	244	−8	36	40	−4	21	20	1	27	27	0
June	10	162	213	−51	34	34	0	21	20	1	22	30	−8
June	20	67	130	−63	26	26	0	18	18	0	18	26	−8
Var. × Dates													
F value		5.98			4.59			16.63			15.20		
5% point		2.22			1.96			2.22			2.22		
1% point		3.07			2.55			3.07			3.07		
SE_M of 5 plots		3.7%			7.2%			1.7%			1.9%		

As mentioned previously the dates of sowing were randomized in each replicate. To reduce competition between dates, two extra border rows were sown on the edges of every dates of seeding plot. Thus centre rows

sown at different times were separated by seven feet with six rows growing between them. Number of spikes per foot was obtained by counting six one-foot sections of stubble as in 1932 and 1933. Sixteen spike samples were taken from each plot in the five replicates. The weight per thousand kernels was obtained by the same method as in 1933 and 1934.

The relative behaviour of Reward to Marquis (Table 5) was different in 1935 to that shown in any other year, in that Reward outyielded Marquis in the first sowing. Generally, however, Marquis was superior in the early sowings and Reward superior in the later ones. The interaction was highly significant. In number of spikes per foot the varieties again showed a different response to dates of sowing. As in previous years this interaction took the form of a difference in the behaviour of the varieties between one date and the next, rather than a general tendency between early and late sowings. This type of interaction stands in marked contrast to the type of interaction usually found in the case of number of seeds per spike. The interaction of varieties with dates of sowing for number of seeds per spike was highly significant. In the early sowings Marquis had five or six seeds per spike more than Reward. Later sowing, however, continually decreased the number in Marquis, but had very little effect on Reward until there was practically no difference in the size of the spikes of the two varieties. Weight per thousand kernels showed a highly significant interaction. To a large extent this was due to the severe attack of rust in the late sowings, which had a particularly damaging effect upon Marquis.

Marquis again owed any superiority in yield to its having longer spikes, which character was set against the advantage of Reward in number of spikes and weight of seed. Reward seemed able to produce high yields only when conditions were favourable to prolific stooling because it seemed unable to make any marked adjustment in size of spike.

SUMMARY OF 1932, 1933, 1934 AND 1935 RESULTS

In Plate I the average results for each character studied are shown graphically in Figures 1, 2, 3 and 4. A generalized "lowest significant difference" between the means of the varieties at any one date for the four years is given for each of the characters: yield, stubble in one foot and seeds per spike. Because the 1000-kernel weight was taken in 1932 on the bulked replicates an analysis of the four years results were not made for this character. In the case of yield and stubble in one foot the four years results were analysed by the variance method. The SE for the four years for number of seeds per spike was obtained by using the formula $1/N\sqrt{a^2 + b^2 + \text{- - -} + n^2}$.

The average of the 1932, 1933, 1934 and 1935 yields for each variety at each date of sowing is shown in Figure 1. The tendency, noted in the results for individual years of Marquis to outyield Reward in early sowings but for Reward to outyield Marquis in late sowings, is very evident. A variance analysis of the four years results proved this difference in response to be highly significant. A significant interaction of varieties with dates with years showed that the response of the varieties to time of sowing had not been the same in each year. The large interaction of dates with varieties was due to Reward suffering less than Marquis from late sowing rather than to the varieties showing a preference for different dates of sowing. Neither

variety yielded its best in the earliest sowing, and in both the yield dropped sharply after the third sowing, the highest yield having been obtained at the second date.

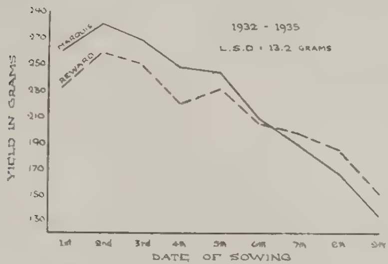

FIGURE 1 AVERAGE YIELD PER ROW IN GRAMS

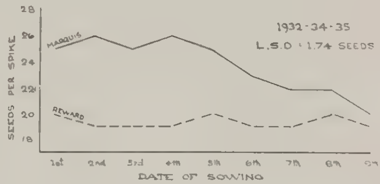

FIGURE 3 AVERAGE NUMBER OF SEEDS PER SPIKE

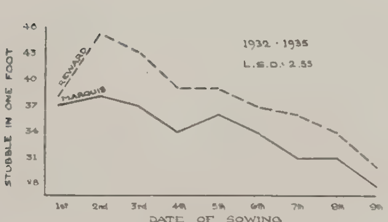

FIGURE 2 AVERAGE STUBBLE COUNT PER FOOT.

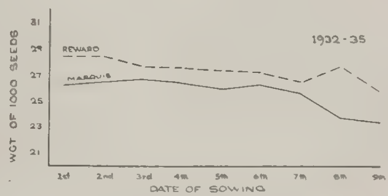

FIGURE 4 AVERAGE WEIGHT OF 1000 KERNELS

PLATE 1

NOTE - L.S.D. = LOWEST SIGNIFICANT DIFFERENCE

In Figure 2 the results of the four years' test for number of spikes per plot are presented. The analysis of the four years results showed the interaction of varieties with dates to fall short of the odds required for significance. However, the second order interaction of varieties with dates with years was highly significant. In other words the particular response of variety to time of sowing depended to a large extent upon the year in which the sowing was made. This confirms the observation made previously (in the discussion of the results for the individual years) that the number of spikes per foot, or roughly, the amount of stooling was particularly amenable to environmental influence, and that fluctuations in moisture and temperature from one week to the next often produced pronounced effects upon this character. It has also been noted that the response of the varieties to these varying conditions was not the same and that Reward exhibited much more variability for this character than did Marquis. That is, Reward responded more readily to, and to a greater degree than, Marquis to conditions which favoured stooling. However, the conditions most favourable for prolific stooling in Reward were not necessarily the most favourable for Marquis.

The average results obtained in 1932, 1934 and 1935 for number of seeds per spike may be seen in Figure 3. It is evident that this character

was largely responsible for the interaction of varieties with dates seen in Figure 1. In neither variety was number of seeds per spike readily influenced by environment. This was especially true of Reward. Even the latest sowing did not reduce the length of its spikes. In Marquis there was a gradual but very marked reduction in the number of seeds per spike as the date of sowing became later, until the advantage of seven seeds which it enjoyed over Reward in some of the early sowings was reduced to one in the last sowing.

Figure 4 shows the results of 1932, 1933, 1934 and 1935 for weight per thousand kernels. The influence of date of sowing upon the kernel weight of the two varieties was, on the average, slight. This was not so however in the individual years. The weight of seed of the two varieties was not affected consistently in the different years by date of sowing. This perhaps was to be expected since the development of the seed would be influenced largely by conditions during the filling stage. Since weather during this period is by no means regular or constant in different years it is not likely that date of sowing would have a marked effect upon the average of several years results for this character.

Generally, in the early sowings, Marquis outyielded Reward. It had a very marked superiority over Reward in number of seeds per spike which more than offset the advantage of Reward in number of spikes per plot and weight of the seeds. These differences have also been observed by Waldron (14). Late sowing had very little effect upon weight of seed. The number of spikes per foot were reduced in the late sowings at approximately the same rate in both varieties. The number of seeds per spike was scarcely affected at all in Reward, but markedly reduced in Marquis; the final result being that when the varieties were sown after June 1, Reward outyielded Marquis.

DISCUSSION

The distinct differential response of wheat varieties to time of sowing as established by the results of this study affords a definite basis for the improvement of comparative variety tests. That new varieties are now tested at several stations for a period of years indicates that a differential response of varieties to wide variations in environment has been recognized. However, the extreme sensitivity of varieties to environment, as demonstrated in this study, indicates that this may not be a sufficiently comprehensive comparison of varieties. It is not unreasonable to suppose that varieties will respond differentially, not only to different dates of sowing, but also to other variations in treatment such as different rates of sowing or different kinds and quantities of fertilizer. That such may actually be the case has been shown by Engledow (2) who sowed wheat varieties at different spacings and by Gregory and Crowther (8) in studying barley varieties with different fertilizers. Thus different cultural treatments together with the many soil and climatic combinations existent in Western Canada represent a large number of varied environments, the effects of which even upon the leading varieties grown in that area are, at present, largely unknown.

In view of the importance of yield of wheat in our national economy and the many difficulties which it presents to the cerealist, the scarcity of

information concerning important yield characters and their relation to environment, is surprising. Unfortunately, in this study, financial conditions rendered it impossible to relate the development of the yield characters which were studied, to environment. The results of such a study might enable the experimenter to draw general conclusions with regard to the possible adaptation limits of a variety, concerning both locality and cultural treatment, and in this way remove a portion of the burden of variety testing.

The possibility of the use of yield analysis by the plant breeder naturally suggests itself. It seems probable that analytical studies of yield might remove a portion of the uncertainty which yield inflicts upon the breeding program by facilitating a more logical choice of parent varieties and by furnishing a lead for selection in the hybrid generations.

SUMMARY

The two wheat varieties, Marquis and Reward, were sown in replicated plots at nine weekly intervals in four successive seasons. Yield per plot was subdivided into: Number of spikes per plot, number of seeds per spike, and weight per seed; these were studied in conjunction with yield.

The varieties responded differently to being sown at different times. The difference in response varied somewhat in different seasons but usually when the varieties were sown early Marquis outyielded Reward while in late sowings Reward gave the higher yield. This was due to Marquis having shorter spikes in the late than in the early sowings. The spike length of Reward was affected very little, number of spikes per foot being the cause of most of the variation in the yield of Reward.

The results were considered to ascribe a new significance to the fundamental reactions of varieties to variations in environment, and to suggest the use of yield analysis to indicate the adaptation limits of varieties.

ACKNOWLEDGMENTS

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Résumé

L'effet des dates des semailles sur le rendement comparatif de deux variétés de blé. W. H. Horner, Université de Saskatchewan, Saskatoon, Sask.

Les deux variétés de blé Marquis et Reward ont été semées à intervalles de neuf semaines en quatre saisons successives sur des parcelles en double. Le rendement par parcelle a été subdivisé comme suit:—nombre d'épis par parcelle, nombre de grains par épi, et poids par grain; ces facteurs ont été étudiés par rapport au rendement. Les variétés semées aux différentes dates se sont comportées de façon différente. Ces différences variaient naturellement quelque peu, mais généralement, lorsque les variétés étaient semées de bonne heure, le Marquis rendait plus que le Reward, tandis que lorsque les semailles se faisaient tard, c'est le Reward qui donnait le plus gros rendement. Cette différence de rendement s'explique par le fait que le Marquis a des épis plus courts quand il est semé tard que lorsqu'il est semé de bonne heure. La longueur de l'épi du Reward n'était que très peu affectée, et le nombre d'épis par pied est la cause de la plupart des variations de rendement de cette variété. On considère que ces résultats donnent une nouvelle signification aux réactions fondamentales que manifestent les variétés dans les différentes conditions de milieu; ils indiquent que l'analyse du rendement serait utile pour indiquer les limites d'adaptation des variétés.

A YELLOWING OF ALFALFA DUE TO BORON DEFICIENCY[1]

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In the Okanagan and Kootenay valleys in British Columbia, a distinctive yellowing and stunting of alfalfa have been found to occur quite commonly in almost every section where alfalfa is grown. This is true whether it is grown as a hay crop, or as a cover crop in the orchard. It is the purpose of this paper to describe the characteristic symptoms of this type of yellowing, and to present a preliminary report of tests which indicate that it is due to a deficiency of boron in the plant.

SYMPTOMS

The type of discoloration found on the alfalfa plant varies with the severity of the disease. In mild cases the leaves turn a light green, while in more severe cases they become distinctly yellowish. The discoloration is usually evenly distributed over the inter-costal area of the leaf; though if the leaf is fully formed before changing colour, the yellowing frequently occurs as streaks running parallel to the veins. This last condition is more marked in some areas of the leaf than in others, giving the surface a splotchy appearance. In severe cases, the yellowing may affect the growing points, so that the new leaves, as they appear, are quite yellow; they remain small in size, and the growth of the tip practically ceases. Frequently the leaves, instead of turning yellow, take on a bronze or reddish colour. Sometimes both the yellowing and the bronzing occur on the same leaves. The midrib and veins, however, normally remain green, and the leaf is usually greener towards the base. Frequently the edge of an affected leaf turns whitish, and the marginal tissue dies, shrivels, and curls upwards.

The time of the first appearance of the yellow colouring depends largely on the severity of the disease. If the plants are not severely affected, the first growth in the spring or after cutting is normal green in colour. Before long, however, the yellowing appears—sometimes before the leaves are fully formed, sometimes after. In severe cases, the young leaves are yellow as they unfold; although it is more usual for the upper leaves to become yellow only after they are well formed, and for the lower leaves to change colour only after the upper leaves have done so.

Accompanying the yellow or bronze discoloration of the foliage, there is a distinct shortening of the internodes. The leaf petioles, however, appear to be about the same length on diseased and on healthy plants. There is no proliferation of the growing points. The general effect is a stunting of the plant and a flattening-out of the upper and more severely affected portions, giving a squat appearance.

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FIELD TESTS WITH BORON

In field tests conducted at Kelowna for the control of drought spot and corky core of apple (1), boric acid and borax were applied to the soil around a number of trees. Applications were made on March 7, 1936, at rates varying from two ounces to four pounds per tree, and again on March 25 at rates of one ounce to four pounds per tree. In each case, the material was scattered by hand within the outermost spread of the limbs—a distance of about seven feet from the trunk of the tree. The materials were disced in early in April. The soil in these plots was a shallow, sandy loam, of a type readily leached by the irrigation water. The cover crop consisted of a mixture of alfalfa, weeds, and grasses. In spite of all attempts to maintain good soil moisture and good cultural conditions, the alfalfa had for some years shown the characteristic symptoms of the yellowing described above.

The effects of both the boric acid and the borax on the alfalfa were quite marked. The two-ounce applications of March 7 produced a slight improvement in the colour and growth of the alfalfa; the four-ounce applications produced a marked improvement; and the eight-ounce applications produced a still greater improvement and gave the greatest total growth during the season. On the other hand, four ounces per tree produced some slight browning and curling of the leaf margins; while with the eight-ounce, one-pound, two-pound, and four-pound applications this type of injury increased progressively, until in the last case a large proportion of the alfalfa was killed outright. Both the beneficial effects of the lesser applications and the harmful effects of the heavier applications were much less in evidence later on in the season. The effects of the March 25 applications were very similar to those just described. In all cases, the alfalfa situated beyond the areas of application continued to show considerable yellowing of the foliage and stunting of the growth.

CHEMICAL ANALYSIS

Analyses were made of the stems and of the leaves for their boron contents. The method of analysis was that recommended by Wilcox (2,3). the procedure being to dry the sample, ash it, convert the boron into methyl

TABLE 1.—COMPARISON OF THE BORON CONTENT OF THE LEAVES FROM GREEN AND FROM YELLOWED ALFALFA PLANTS

District	Farm No.	Colour of leaves	Boron content (p.p.m. dry weight)
Summerland	1	Green	32.20
		Yellow	4.30
	2	Green	26.00
	3	Yellow	9.50
	4	Green	29.90
Northport, Washington	1	Green	16.10
		Yellow	7.86
	2	Green	17.90
		Yellow	6.53
	3	Green	14.50
		Yellow	3.66

borate by distilling with methyl alcohol, saponify the distillate with sodium hydroxide, and titrate the boric acid in the presence of mannitol.

Samples of green and of yellowed alfalfa plants were collected from fields and orchards in the Summerland district in British Columbia and in the Northport district in the State of Washington. The "green" samples from Northport were not of as deep a green as those from Summerland, there being some evidence of incipient yellowing in the former. In both districts the two types of plants were found in different parts of the same field or in nearby fields. The results of these boron analyses are given in Table 1. It will be observed that in every case the boron content was considerably lower in the yellowed plants than in the green plants.

On June 25, 1936, alfalfa plants were collected from around those trees that had been treated with boric acid on March 7. The results of these analyses are shown in Table 2. It will be noted that the leaves and stems of the untreated plants were very low in boron.

TABLE 2.—BORON CONTENT OF ALFALFA PLANTS TREATED WITH BORIC ACID

Amount of boric acid applied per tree area	Boron content (p.p.m. dry weight)	
	Leaves	Stems
None	11.4	2.2
4 oz.	214.0	15.8
8 oz.	344.0	20.4
1 lb.	439.0	31.2
2 lb.	698.0	—
4 lb.	734.0	90.4

SUMMARY

1. A distinctive type of yellowing of alfalfa, commonly found in the interior of British Columbia, is described.

2. Small applications of either boric acid or borax to the soil were found to remedy this yellowing. Larger applications produced injury from excess boron.

3. The boron content of the yellowed alfalfa plants was found to be consistently lower than that of the green plants.

ACKNOWLEDGMENT

The writers wish to acknowledge the assistance given by Dr. G. A. Ledingham of the Canadian National Research Council in the collection of samples of alfalfa leaves from the Northport area.

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Résumé

Un jaunissement de la luzerne dû au manque de bore. H. R. McLarty, J. C. Wilcox et C. G. Woodbridge, Laboratoire fédéral de pathologie végétale, Summerland, C.B.

Un type bien net de jaunissement de la luzerne, généralement trouvé dans l'intérieur de la Colombie britannique, est décrit dans cet article. On a réussi à le prévenir en appliquant au sol de petites quantités d'acide borique ou de borax. Quand les quantités étaient plus fortes, il y avait un surplus de bore qui exerçait une action néfaste. Il a été constaté que la teneur en bore des plantes de luzerne jaunies était toujours plus faible que celle des plantes vertes.

BACTERIAL WILT AND ROT OF POTATOES[1]

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[Received for publication, April 16, 1937]

INTRODUCTION

The presence of an apparently new disease of potatoes was observed in 1931 by the Dominion Seed Potato Certification Service in several localities of the province of Quebec, as recorded by Conners (4). The attention of the inspectors was directed to this disease through the unusual combination of a wilting of the plants in the latter part of August and severe internal decay of the tubers in the field and during the storage period. Since this first observation, surveys reported by Baribeau (1) and Conners(5) indicate that the trouble has become widely distributed throughout the province. Bonde (2) has recently described the presence of a disease with similar symptoms in Maine, where it has been reported since 1932. In the autumn of 1936 the same trouble was found in tubers harvested from a planting at the Central Experimental Farm, Ottawa. It is not known whether the plants in this field exhibited wilting, for it was only discovered in the stored tubers. It is of interest to note that in 1918 E. F. Smith (7) received tubers from Berkshire Co., Mass., showing strikingly similar symptoms and he suspected that the infection was caused by *Phytomonas michiganensis* (E. F. Smith) Bergey *et al.*, the causal organism of tomato canker, though he was unable to isolate the pathogen.

The importance of this disease was recognized in the early years of its occurrence and preliminary work was undertaken by the Ste. Anne de la Pocatière and Ottawa laboratories. In the autumn of 1936 the Dominion Botanist extended this project to include the authors, up to that time the causal organism not having been found. As a result a bacterial organism has now been isolated for which adequate proof of pathogenicity has been obtained.

Long before the disease received critical study in the laboratory, it had become widely known as "Bacterial Wilt". This term was not considered sufficiently distinctive, because of its possible confusion with other wilt diseases of the potato caused by bacteria. Since the disease includes a specific tuber rot, the authors have decided to use a term combining the vine and tuber symptoms and propose to have this disease known by the popular name, "Bacterial Wilt and Rot" (Flétrissure bactérienne et Pourriture).

SYMPTOMS OF THE DISEASE

The symptoms show considerable variability. In the greenhouse the first sign of infection is often a flagging of individual leaflets during periods of sunshine. Later, infected leaves may show an upward rolling of the edges or lesions with yellow margins superficially resembling those caused by late blight. Finally, the leaflets become permanently wilted and

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[2] Graduate Assistant and Plant Pathologist, respectively.

shrivelled. The petioles of mature leaves usually remain rigid, though young petioles and the stem tip may wilt before shrivelling. In the field the symptoms are probably not so marked and may tend to be masked by other injuries in the early stages.

More characteristic, perhaps, are the tuber symptoms; affected tubers show yellowish or light brown discoloration of the vascular ring, spreading in all tubers so far examined, from the stolon end; later there may be more extensive dark brown discoloration, general rotting of the tubers and, occasionally, a distinctive separation of the cortex and outer storage parenchyma from the storage parenchyma lying inside the xylem ring. How much of the severe rotting found in the later stages is due to the pathogen and how much to secondary organisms is still to be decided. It should be stressed that the rotting produced by the pathogen is not precisely that generally understood by the term "soft rot"; the invaded tissues are not slimy but crumbly, with the consistency of cooked potato tissue. Slightly affected tubers generally show no external symptoms; severely affected ones may show cracking or reddish-brown discolorations of the skin. Some tubers decay completely, while others still show very slight symptoms in the spring.

ISOLATIONS FROM DISEASED TISSUE

Isolations were made from affected tubers grown locally and from some supplied by Mr. B. Baribeau from Megantic Co., Que. From severely decayed tubers a variety of fast-growing organisms was generally procured, but from the vascular ring of very slightly affected tubers, abundant colonies of a surprisingly slow-growing, small, Gram positive, short rod were obtained on potato dextrose agar plates after 12–17 days; the culture of this organism on ordinary potato dextrose agar slants proved virtually impossible. At the kind suggestion of Dr. C. B. Taylor, Division of Agricultural Bacteriology, Central Experimental Farm, experiments on the effect of yeast extract were tried; it was found that 0.2 gram of Bacto Yeast Extract and about 15 cc. of normal sodium hydroxide added to a litre of potato-2% dextrose agar yielded quite satisfactory growth. It should be stated, in passing, that tubes of this medium should be used within about four weeks of preparation, as subsequently growth on it becomes decidedly slower.

The organism is evidently very closely related to both *Phytomonas michiganensis* (E.F.S.) Bergey *et al.*, the cause of bacterial canker of tomatoes, and *Bacterium sepedonicum* Spiekermann (*Phytomonas sepedonica* according to Bergey's terminology which is here adopted), the cause of bacterial ring rot of potatoes, a disease recorded from Germany and very similar to the one here described. It seems doubtful whether this organism can be considered identical with either of the above; its growth rate is decidedly slower and its pathogenicity to tomatoes appears to be markedly greater than that of *P. sepedonica* as described by Stapp (8). Typical strains of *P. michiganensis* on the other hand do not attack potato as shown by Bryan (3) and by Stapp (9). The growth on potato dextrose agar is dull white to cream or light buff; in this characteristic and its temperature relationships it is very similar to *P. sepedonica*. It is not advisable to attempt to name the pathogen until further comparisons with these two organisms have been carried out.

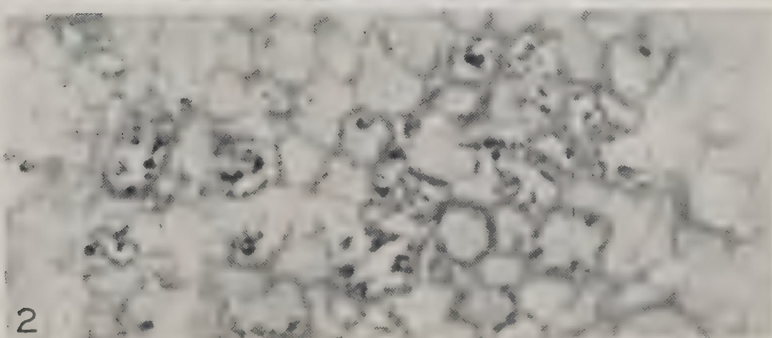
PATHOGENICITY OF THE ORGANISM ISOLATED

Inoculations were made into the stems of young tomato and potato plants, by pricking through a suspension of the organism with a fine needle. Inoculation into tomato stems resulted in symptoms virtually indistinguishable from those caused by *P. michiganensis* except that few external cracks occurred. The first signs of wilting occurred in nineteen days and all plants were severely affected in about five weeks after inoculation; extensive yellow-walled cavities were formed in the stems and the plants soon died. Whether the symptoms will prove to be equally pronounced out of doors, and in plants that are larger at the time of inoculation, remains to be seen. In potatoes, stem inoculations proved successful in all cases, the first signs of wilting being seen in about two to four weeks. At first, wilting was largely temporary, being marked on bright days when the temperature of the greenhouse was moderately high; it was soon followed by curling or yellowing of the leaf edges, as can be seen in Figure 1, and, eventually, by necrosis of the discolored areas and permanent wilting of the leaflets concerned. Figure 1 shows two young Green Mountain plants stem-inoculated six weeks before being photographed.

Potato tubers were inoculated either by this method or with a hypodermic needle and either planted in pots in the greenhouse or stored in the laboratory. Inoculation of sets close to the eyes resulted in a slower development of the disease, the first symptoms being observed in six weeks, while one plant still shows no signs of wilting nine weeks after inoculation. Inoculation of dormant tubers resulted in a slowly spreading, yellowish, crumbly rot, which, after 14 days, had attained a maximum spread of about one-quarter of an inch. After 32 days the decay in the storage tissue had progressed slightly further and the organisms were found in the vessels as much as one inch from the point of inoculation. The microscopic appearance resembles that of natural infections, except for those differences inherent to a variation in the method by which the organism is introduced. In naturally infected tubers, the invasion is primarily vascular and the bacteria gradually escape from the vessels into the intercellular spaces, while inoculation of the tuber by needle puncture results in an invasion which is primarily intercellular with later invasion of the vessels. Numerous colonies of the same organism were obtained in about seven days, by plating from diseased tissues with freshly prepared neutral yeast extract potato-dextrose agar. With old medium the colonies took longer to appear and were usually very few in number.

FIELD DIAGNOSIS OF THE DISEASE

In every potato and tomato plant examined, by the time a leaf shows symptoms of the disease it is already quite heavily invaded by the bacteria. Figure 2 is a cross-sectional view through the xylem of one of the five bundles of a potato leaf petiole, one leaflet of which had commenced to wilt. The section was stained by a modification of the method described by Jones (6) which is very satisfactory for this material. All the deeply stained matter represents bacterial masses, the degree of magnification being insufficient to resolve the individual organisms. The photograph was taken with Spencer's apochromat objective, N.A. = 0.95 with the condenser at N.A. = 0.85 and a Wratten B filter.



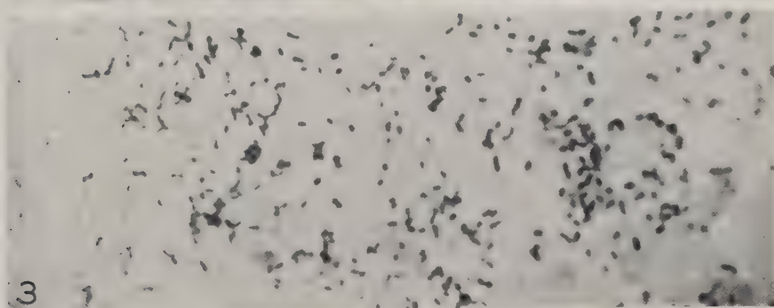


FIGURE 1. Potato plants inoculated with bacterial wilt and rot pathogen. FIGURE 2. Bacterial masses in xylem of potato leaf petiole. ×610. FIGURE 3. Gram-stained preparation of bacteria from petiole. ×1870.

In determining the early invasion of the tissues by the bacteria, a technique was evolved which it is hoped will be of aid in making earlier and more reliable field diagnoses. It is suggested that boxes of slides numbered, preferably by means of a writing diamond, be carried during field inspections; any suspicious-looking leaves or stems are severed below the abnormal area with a thoroughly cleaned knife and the cut end gently tapped on a slide. It is neither necessary nor desirable that force be used, since this merely tends to cover the preparation with plant fragments. The deposit so made is allowed to dry and, on return to the laboratory, it is fixed by heat like an ordinary bacterial smear, Gram-stained and examined under an oil immersion lens; the presence of masses of Gram positive rods measuring about $0.3–0.5\mu \times 0.6–0.9\mu$ is a definite indication of the presence of this disease. Figure 3 shows a portion of such a smear photographed through Spencer's oil immersion apochromat objective N.A. = 1.3, apochromat immersion condenser at about N.A. = 1.1 and a Wratten K3 filter. The presence of a few scattered organisms is to be regarded with doubt as it may be caused by insufficient care in cleaning the knife after cutting through an infected plant, for if a single vessel is invaded there should be a large number of organisms somewhere on the smear. The knife used should be sharp and free from nicks or rough spots, which might retain bacteria, and it is suggested that immediately before and after use it be wiped with a small wad of sterile absorbent cotton moistened with alcohol from a vial or small bottle, each piece of cotton being discarded after use. Some six or eight smears can be made on a slide if it is suitably ruled, and if a regular sequence is used it is only necessary to number the slide and not the individual squares. The pertinent information can be recorded in a note-book opposite the number of the slide and smear.

Acknowledgment is due to Dr. F. L. Drayton and Mr. I. L. Conners of this Division for many helpful suggestions. Thanks are also due to Miss Edna Fawcett of the Bureau of Plant Industry, Washington, D.C. and to Drs. M. W. Gardner and P. A. Ark of the University of California, Berkeley, California, for cultures of *P. michiganensis*.

SUMMARY

"Bacterial wilt and rot" of potatoes has been observed in Quebec since 1931. There are reasons to believe that it is present in other parts of Eastern Canada and the United States. The affected plants commonly wilt in August, and the tubers show a discoloration of the vascular ring and become completely decayed. A slow-growing bacterium, capable of reproducing the disease and of producing on tomatoes a disease similar to bacterial canker, has been isolated. The organism will not be named until full comparisons with *Phytomonas michiganensis* and *P. sepedonica* have been completed. A method of making smear preparations of the pathogen from the diseased plant, while in the field, has been outlined, in the hope that it will make possible early and positive diagnosis of the disease.

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Résumé

Brûlure et pourriture bactériennes des pommes de terre. D. B. O. Savile et H. N. Racicot, Service de la Botanique, Ferme expérimentale centrale, Ottawa.

L'existence de la "brûlure et de la pourriture bactérienne" est connue dans la province de Québec depuis 1931 environ, et il y a lieu de croire que cette maladie sévit également dans d'autres parties de l'est du Canada et des Etats-Unis. En général, les pieds affectés se flétrissent en août, et les tubercules exhibent une décoloration de l'anneau vasculaire et pourrissent complètement. Une bactérie à végétation lente, susceptible d'engendrer la maladie et de produire sur les tomates une maladie semblable au chancre bactérien a été isolée. Cet organisme ne sera nommé que lorsqu'on aura pu faire des comparaisons avec *Phytomonas michiganenis* et *P. sepedonica.* On a devisé un moyen de faire des préparations en frottis du pathogène extrait de la plante malade dans le champ, dans l'espoir que ces préparations permettront d'établir un diagnostic positif de la maladie à ses débuts.

SOME VARIABLES IN EXPERIMENTAL SEEDERS

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INTRODUCTION

Machine seeding of some order has superseded hand planting on most Canadian experiment stations. This effort to speed up seeding operations and render them more accurate has led to the development of several new types of experimental seeders. The present paper presents the results of an effort to determine some of the variables encountered in the use of any hand seeder and to compare in this regard the newer types of experimental machines with commercial hand planters.

Four different types of seeders were used. These were: the Planet Junior garden seeder, the seed output of which is regulated by a metal disc with a series of apertures of varying size; the Columbia garden seeder of the cylinder feed type; and two of the newer types of seeders developed by Kemp at the Swift Current, Sask., Experiment Station. The two latter types were the endless belt seeder christened for class purposes "Kemp V-belt seeder", and the fluted ring seeder, also renamed "Kemp disc-seeder".

Cuts or written descriptions of the seeders will not be attempted, as the commercial types are too well known to need comment, and the newer machines are adequately described and illustrated in a paper recently published by Kemp (1).

The Problem

In the case of all seeders it was desired to determine if there was any definite tendency toward periodicity of drop. To secure such information the number of kernels dropped per inch of seeding distance was recorded in the form of a graph. With the two later model seeders, the rate of drop per four inch intervals was recorded, as well as the distance in centimetres between seeds. In this manner a fairly reliable index was secured of the smoothness of seeding and of the accuracy of delivery of the seeds.

Both of the later model seeders are so constructed that all of the seed that they contain is delivered in a predetermined distance, hence no variation could be expected in this particular. The Planet Junior and Columbia seeders, on the contrary, are hopper types and may contain sufficient seed for the planting of many small units. Machines of this type might be expected to vary with changed operating conditions. Two variable factors were investigated; namely, the amount of seed which the hopper contained and the speed at which the seeders were operated. The results of these latter determinations are presented in the form of tables.

Methods Used

In all instances the seeding was done in the laboratory and under conditions paralleling as closely as possible those obtaining under field operation. In the instance of the Planet Junior and Columbia seeders,

[1] These tests were undertaken as a senior year laboratory project with the following plant science students at the University of Manitoba: W. R. Allen, L. Carter, R. Glentworth, A. Harrison, R. Milne, J. H. Nichol, R. G. Reynolds, and J. F. Twomey.

an 18.5-foot space was marked off on the floor and the tests conducted over this measured distance.

In checking the influence of speed of operation the regular shoe was removed from the seeders and a small pan used to catch the seed. It was found that the machine carried the container along with it in a very satisfactory way, and caught all the seed without difficulty. The seed thus delivered was accurately weighed to the nearest tenth of a gram. All operations were repeated at least ten times.

The determinations of the accuracy of drop per unit area at first presented some difficulty because of the bouncing of the seeds on the floor as they dropped. This was overcome by first fastening heavy brown paper to the floor and then coating it with a thin layer of cup grease. Seeds dropping on this prepared surface remained absolutely as they fell. The desired measurements were then readily obtained.

Wheat was used as the main type of grain for the various experiments However, in some instances similar tests were conducted with barley and with oats. Plump grain of good quality was used throughout. It is realized, of course, that different results might be expected where light grain was used, but as the great bulk of seed used is of a better type, no attempt was made to check seed quality as a variable. The hopper seeders were calibrated to deliver approximately the amounts used locally in plot tests. Corresponding amounts were also used with the newer types of seeders.

EXPERIMENTAL RESULTS

1. Periodicity of Drop

Chart 1 indicates a very appreciable tendency for a periodic drop in the case of both the Planet Junior and the Columbia seeders. While slightly wider fluctuations are apparent in the Columbia seeder graph

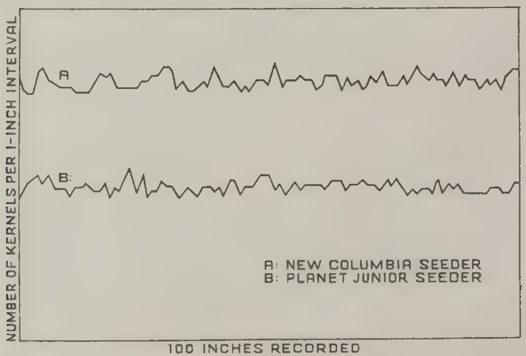

FIGURE 1.—Fluctuations in seeding wheat with various seeders.

than in the case of the Planet Junior, it is doubtful if one can be claimed to be much superior to the other in this regard. Undoubtedly the two hopper types of seeders fall considerably short of uniform delivery of seed.

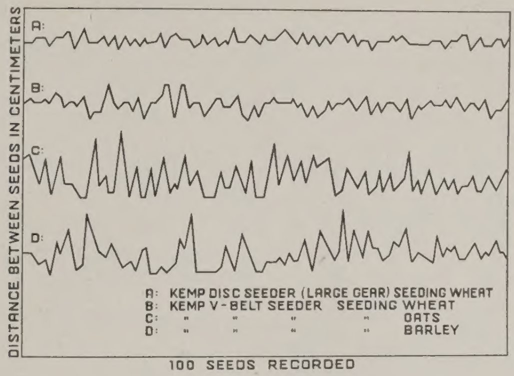

FIGURE 2. Fluctuations in uniformity of seeding.

Graph (A) presents the results secured with the Kemp disc seeder modified by speeding up the rate of travel of the fluted ring to empty the contents of a single division at 2-inch intervals instead of at approximately 4 inches as originally constructed. This machine has given reasonably satisfactory results as a head row seeder where it is desired to space the seeds so that they retain their individual identity. In no instance were two seeds dropped together and while there was some variation in the distance between seeds, the planting would be considered fairly satisfactory in this regard. The most serious disadvantage of the machine under discussion, used as a head row planter, is the necessity of placing the individual seeds in the separate compartments of the fluted ring. Unless some mechanical distributor could be constructed, the slowness of operation would mitigate against the effective use of the planter.

Graph (B) illustrates the variation occurring in the continuous belt seeder used for planting head rows. While considerable variation is evident in the distance between seeds, this should be appreciably lessened when seeding in soil as the shoe would tend to prevent the deviation sideways that was recorded under the experimental conditions.

An attempt was made to ascertain the accuracy of the V-belt seeder in the planting of head rows of oats and of barley. The results depicted by the graphs (c) and (d) indicate in no uncertain manner that the accurate planting of oats and barley is not accomplished by the machine in question with anything like the degree of success that was associated with the seeding of wheat. The seeds of both of the oats and barley appeared to stick to the rubber and failed to drop with regularity.

The uniformity of distribution per each 4 inches of row in the instance of the Kemp disc seeder and the Kemp V-belt seeder was particularly good and should be considered quite satisfactory.

The ease of placing the seed in the V-belt, coupled with the fairly satisfactory seeding performance, places the V-belt seeder in the front rank of experimental seeders developed to date as far as the planting of wheat is concerned.

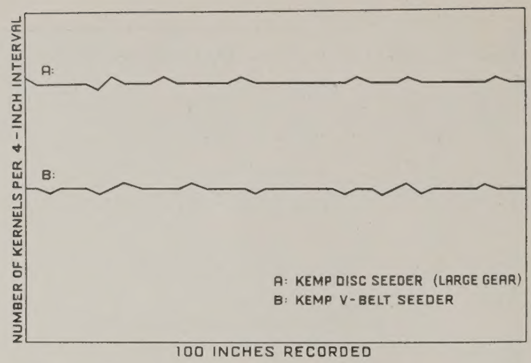

FIGURE 3. Fluctuations in seeding wheat with various seeders.

2. Influence of Method of Operation on the Quantity of Seed Delivered

Tables 1 and 2 present the results secured with the Columbia and the Planet Junior seeders operated at different speeds and with different amounts of seed in the hopper.

(a) Speed of Operation

In this instance the machines were operated at fast, medium and slow rates of speed. The fast speed entailed covering the 18.5-foot distance in from 4 to 5 seconds; the medium in 10 to 12 seconds and the slow in 18 to 20 seconds.

TABLE 1.—INFLUENCE OF SPEED OF OPERATION

Machine	Fullness of hopper	Kind of grain	Grams seed delivered per 18.5 foot row, each figure being the average of ten trials					
			Fast	5% point	Medium	5% point	Slow	5% point
Planet Jr.	Full	Wheat	11.9	±1.144	15.5	±1.208	17.7	±1.972
Planet Jr.	Half full	Wheat	11.5	±1.372	14.8	±1.090	17.3	±1.570
Planet Jr.	Nearly empty	Wheat	11.8	± .594	14.9	±1.194	17.1	±1.514
Columbia	Full	Wheat	14.0	± .540	14.5	± .604	14.7	± .766
Columbia	Half full	Wheat	13.5	±1.056	13.9	± .552	13.7	± .794
Columbia	Nearly empty	Wheat	12.2	± .680	12.2	± .812	12.5	± .758

Table 1 presents evidence indicating that the speed of operating the Planet Junior seeder has a very definite influence on the amount of seed delivered. The slower speed in all instances was responsible for the delivery of an increased quantity of seed. This relationship persisted irrespective of the fullness of the hopper.

A similar test conducted with the Columbia seeder failed to react in the same way as the Planet Junior. Speed of operation apparently had no significant effect on the quantity of seed delivered. This relationship was not altered by varying the quantity of seed in the hopper.

(b) *Influence of the Fullness of the Hopper*

Table 2 presents the results secured with each of the two seeders under discussion, when the speed of operation was held at a medium speed and the quantity of seed in the hopper varied. In this test oats and barley were checked in addition to wheat.

TABLE 2.—INFLUENCE OF FULLNESS OF HOPPER

Machine	Speed of operation	Kind of grain	Grams seed delivered per 18.5 foot row, each figure being the average of ten trials					
			Hopper full	5% point	Hopper half full	5% point	Hopper nearly empty	5% point
Planet Jr.	Medium	Wheat	15.5	±1.208	14.8	±1.092	14.9	±1.194
Planet Jr.	Medium	Barley	17.6	±1.976	19.4	±1.600	16.5	±1.490
Planet Jr.	Medium	Oats	9.8	±1.890	8.4	±1.098	11.5	±1.996
Columbia	Medium	Wheat	14.5	± .604	13.9	± .552	12.2	± .812
Columbia	Medium	Barley	18.3	± .738	16.8	±1.134	16.7	± .586
Columbia	Medium	Oats	17.4	±1.336	16.3	±1.256	14.5	± .910

Where wheat was being tested the Planet Junior showed no significant difference in the amount of seed delivered with different quantities in the hopper. With the Columbia seeder, however, a difference was secured that certainly approaches significance. In this instance a decreased amount of seed was delivered as the quantity of grain in the hopper was lessened.

When oats and barley were tested the results with both types of seeders were somewhat erratic. In no instance did either the oats or barley flow as smoothly as the wheat. In a very few tests the results appear to suggest a possible difference between the methods of operation, but even in such instances the variability between the individual tests was sufficiently marked to obviate definite conclusions.

The tests under discussion only serve to emphasize the desirability of developing a more efficient type of seeder for the experimental seeding of oats and barley.

SUMMARY

Experiments were conducted with four types of hand seeders, two of which were common commercial types, and two were models developed for experimental seeding.

The machines were tested for uniformity of seeding and accuracy of total delivery of seed. The commercial seeders were also checked for variation in quantity of seed delivered when the fullness of the hopper was altered, and when the speed of operation was changed.

In general, the new continuous belt seeder proved to be the most satisfactory for the seeding of eithter head rows or rod rows of wheat.

There was a definite influence of speed of operation on the amount of seed delivered in the case of the Planet Junior seeder. The slower speed in all cases resulted in a larger delivery of seed. No significant influence was secured by varying the amount of seed in the hopper.

With the Columbia seeder the reverse condition was encountered. The speed of operation had no significant influence on the quantity of seed delivered, but increasing the amount of seed in the hopper resulted in apparently significant increases in the amount of seed delivered.

None of the seeders tested were as satisfactory in seeding oats or barley as they were in the case of wheat.

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Résumé

Essais de semoirs. G. P. McRostie, et autres, Université du Manitoba, Winnipeg, Man.

Quatre types de semoirs à bras ont été mis à l'essai; deux de ces semoirs étaient du type commercial ordinaire; deux autres, des modèles spécialement désignés pour les essais de semailles. Ces machines ont été éprouvées pour l uniformité de la distribution des semences et l'exactitude du débit total de semences. Les semoirs commerciaux ont été éprouvés également pour la variation dans le débit de semence quand la trémie était plus ou moins remplie et le fonctionnement plus ou moins rapide. En général, le nouveau semoir à courroie continue s'est montré le plus satisfaisant pour les semailles du blé en rangées d'épis ou en rangées d'une perche. En ce qui concerne le semoir Planet Junior, la rapidité du fonctionnement a exercé une action bien marquée sur la quantité de semence distribuée. Dans tous les cas, le débit de semence était plus considérable lorsque la vitesse était ralentie. On n'a pas obtenu d'influence significative en variant la quantité de semence dans la trémie. C'est tout le contraire que l'on a constaté pour le semoir Columbia. La rapidité du fonctionnement n'a exercé aucun effet significatif sur le débit de semence, tandis que, lorsque la quantité de semence dans la trémie était augmentée, il en est résulté une augmentation apparemment significative dans la quantité semée. Aucun des semoirs à l'essai ne s'est montré aussi satisfaisant pour semer l'avoine ou l'orge que pour semer le blé.